An exploration of an institutional and behavioural analytic framework for technology transfer and commercialization partnerships

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Abstract:
Technology transfer and commercialization partnerships have become a key focus in knowledge based economies. They are deemed a necessary means to translate basic academic research to market based solutions. These partnerships can be considered a special group of public-private partnerships, as they increasingly include universities as a central player.

The objective of this study is to explore the institutional and behavioural underpinnings of technology transfer and commercialization partnerships in an attempt to provide a comprehensive platform for scholars and practitioners in the area to analyse the various key components of these partnerships. To do this, we use the Institutional Analysis and Development (IAD) Framework presented by Elinor Ostrom (2005) to gain deeper understanding of how factors such as community attributes, biophysical and material conditions, and rules impact the interactions between participants in technology transfer and commercialization partnerships.

To understand the impact of behavioural factors on the technology transfer partnerships, we then make use of two key concepts from the area of behavioural decision making: bounded rationality (Simon, 1955) and Prospect Theory (Kahneman and Tverskey, 1979). Based on these theories, and on insights from the IAD framework, we develop an understanding of how cognitive limitations may influence decisions of individual participants in technology transfer and commercialization partnerships.

The theoretical framework is complemented by a case study on Saskatoon's Agriculture Biotechnology Cluster. More specifically, we analyze the initiative to develop the Bio-economy Center of Commercialization and Research (BECCR), which was initiated to pool commercially viable technologies held across various organizations in the cluster. The study confirms our theoretical postulates around institutional and behavioural factors necessary for successful development and functioning of these partnerships. The study shows that cognitive framing of the issue in the context of win-loss opportunities are key behavioural factors while the broad definition of technologies, different organizational cultures, university administrative policies, ILO structure, time frames, faculty attitudes and lack of political are found to be the most important institutional factors.

Key Words: Technology Transfer Partnerships, Institutions, Institutional Analysis and Development (IAD) framework, Bounded Rationality, Prospect Theory

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For my parents

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ACRONYMS

AAFC	Agriculture and Agri-Food Canada
AUCC	Association of Universities and Colleges of Canada
AWB	Ag-West Biotech Inc.
BECCR	Bio-economy Center of Commercialization and Research
CDC	Crop Development Centre
CFI	Canadian Foundation for Innovation
CLSI	Canadian Light Source Inc.
FII	Feeds Innovation Institute
HQP	Highly Qualified Personnel
IAD	Institutional Analysis and Development
ILO	Industry Liaison Office
IPBPC	Innovation Place Bio Processing Center
IP	Intellectual property
IPR	Intellectual Property Rights
NCE	National Centers of Excellence
NRC-IRAP	National Research Council-Industrial Research Assistance Program
NRC-PBI	National Research Council-Plant Biotechnology Institute
NTBF	Newly formed technology based firm
OECD	Organisation for Economic Co-operation and Development
POS	Protein, Oil, and Starch
PPP/P3	Public-Private Partnership
SPG	Saskatchewan Pulse Growers
SRC	Saskatchewan Research Council
U of S	University of Saskatchewan

One

Introduction

1.1. Background

When US president Barack Obama recently delivered the 2011 state of the union address, the message was clear: innovation will determine America's future. The speech focused on the need for effective collaboration between government and the private sector to utilize innovative technologies to drive and sustain economic growth. During his speech, President Obama emphasized the need for government to take a strategic interest in promoting innovation and ensuring that public funding for research gets translated into cutting edge technologies and processes which can be used to the benefit of American economy (Obama 2011).

The message applies not only to the United States but to the wider global community, including Canada. It is both reflective of the governments' concerns for economic growth as well as the role of innovation in establishing the leadership position of a country in the global community. It brings to attention the changing role of knowledge in economic growth and the need to link basic research to economic development. Policy makers have forcefully pointed out that for innovation to play a facilitating role in economic growth, basic academic research needs to be translated into economically beneficial products and processes.

Since the mid-1980s, when the information and bio-technology revolutions swept the global economies, innovation has become an integral part of economic policy. There is now a heightened recognition that a strong domestic innovation capacity contributes not only to long-term economic growth and prosperity but also to various other aspects of public policy related to education, health, the environment, culture and civil society in general (Association of Universities and Colleges of Canada 2008, 3). Consequently, focusing on innovation is considered to be a central driver for economic and social progress.

Evolution of national and regional economies into knowledge-based systems has, however, introduced a great deal of complexity into the world. Technological advances in fields such as biotechnology have created expectations that an increasingly wide range of problems can be researched and addressed in a more holistic fashion and at an accelerated pace. This has led to a stronger focus on knowledge mobilization and applications, which usually adds to the costs of research (Association of Universities and Colleges of Canada 2008, 3). Consequently, it becomes very difficult for any single organizational entity to undertake an end-to-end approach encompassing research, knowledge mobilization and application. Policy makers, research administrators and practitioners have come to recognize that collaborative R&D activities must be heightened across organizational, sectoral, and geographic boundaries if they are to compete and contribute in a global system (Association of Universities and Colleges of Canada 2008, 4). Governments increasingly view enhanced R&D collaboration as a necessary means to achieve economies of scale, address productivity gaps, strengthen knowledge mobilization and commercialization, and improve the overall well-being of their citizenry (Ibid).

With the growing importance of knowledge-based economies and an increased focus on translating knowledge into the economic realm, universities face new challenges. Universities

are now looked upon as providers of both basic and applied research. They are expected to play a much larger role in ensuring that their research activities contribute to the social and economic development of their communities. The literature on innovation systems has increasingly started to ascribe a central position to the universities. Leydesdorff and Etzkowitz (2000), for example, have developed the Triple Helix model to explain the interplay between universities and other public and private organizations in promoting innovation. They assert that 'entrepreneurial universities' feature prominently in government and private sector strategies for innovation. Universities have emerged as an important partner in the innovation systems, responsible for bringing their research to the market. This requires an increased emphasis on technology transfer and commercialization activities; investments in entrepreneurial researchers, technology transfer infrastructure, intellectual property, and outreach are key enabling features for partnerships between universities and others.

Together three pillars--academia, the public sector and private firms—comprise the key organizational actors in technology transfer partnerships. Each organizational sphere is expected to bring different competencies in the production, consumption, and dissemination of knowledge. Technology transfer and commercialization partnerships, which are usually a subset of the broader collaboration between these sectors, are specifically established to translate knowledge from the lab to the marketplace. In this study, we delve into an institutional and behavioural analysis of technology transfer partnerships in an attempt to uncover some of the key underlying factors that facilitate or hamper the development and functioning of these partnerships.

1.2. Study Objectives

Studying research and technology transfer partnerships between academia, government, and private sector is warranted on at least two accounts. First, the infancy of the subject matter means there are many interesting issues that have not been comprehensively theorized. The work that has been conducted so far remains contextual and fails to provide a comprehensive framework that can be applied to multiple situations. None of the past studies have analyzed technology transfer and commercialization partnerships from an institutional perspective, which arguably remains a challenge for scholars of innovation given the complexity of such collaborative initiatives. The literature fails to systematically account for individual behaviours in these partnerships. Investigating the institutional and behavioural underpinnings of partnerships should greatly extend our understanding of these partnerships.

Second, despite the rhetoric many partnerships have not lived up to their promise of delivering measureable economic growth through bringing academic research and technologies into the marketplace. With the exception of a few successful cases, the performance of most technology transfer collaborations has remained below-par. Much of the attention has focused on successful cases which possibly masks important shortcomings in the functioning of technology transfer partnerships.

In this exercise, we undertake an exploratory study of technology transfer partnerships and develop a comprehensive analytical framework that involves theoretically grounded institutional and behaviour analysis. We utilize Elinor Ostrom's Institutional Analysis and Development Framework (IAD) to carry out the institutional analysis of technology transfer partnerships. Further insights into behavioural patterns and cognitive limitations are provided by using the key

concepts of bounded rationality (Simon, 1955) and Prospect Theory (Kahneman and Tverskey, 1979). Pairing the IAD framework with behavioural theory, unconventional as it may be given the nature of our study, allows us to capture both institutional and behavioural underpinnings in a comprehensive manner. More important, the framework allows us to develop a common 'language' around partnerships which has been missing in the studies conducted thus far.

The study uses this framework to undertake an empirical investigation of a specific technology transfer partnership. For this part, we explore the attempts to develop a technology transfer partnership in the Saskatoon-based agricultural biotechnology cluster. More specifically, we delve into a study of a rather unsuccessful attempt between 2006 and 2008, known as the Bio-Economy Center of Commercialization and Research (BECCR). This initiative was undertaken to pool together commercially viable biotechnologies dispersed across many organizations in the cluster. It was hoped that a partnership between various public and quasi-public organizations in the cluster would enable the private sector to efficiently identify these technologies and translate them into the marketplace. The project, however, failed in securing the federal funding and consequently no further attempts have been made to develop the idea. Despite its failure, the initiative can act as a beta-test case for the theoretical framework and provide valuable insights into the institutional and behavioural factors which underlie the development of such initiatives.

1.3. Structure of the thesis

The study is divided into two components: theoretical and empirical. The theoretical component presents the institutional and behavioural analytic framework while the empirical component allows us to map the theoretical postulates from the institutional and behavioural

framework onto a real scenario. Together these two components are used to develop a deeper understanding of technology transfer and commercialization partnerships.

The theoretical framework is presented in chapters 2-4. Chapter 2 includes a review of the literature on technology transfer partnerships. The chapter presents some definitions and concepts related to partnerships along with some key factors which have been identified as facilitating or hindering their development. Chapter 3 adapts the Institutional Analysis and Development Framework (IAD) to build a set of tools necessary for conducting an institutional analysis of technology transfer partnerships. Chapter 4 moves from the broader institutional perspective to the individual level to delve into the behavioural factors affecting the decision making capacities of individuals within technology transfer partnerships. The chapter challenges the rational choice model of decision making and presents some theories on cognitive limitations and human behaviour.

Chapters 5 and 6 present the empirical work. Chapter 5 presents a case study on the Saskatoon Agriculture Biotechnology Cluster, which will allow us to test some of the theoretical postulates developed in chapters 3 and 4. Chapter 6 offers some concluding remarks on technology transfer and commercialization partnerships.

Two

Technology Transfer Partnerships: An Overview

Since turn of the millennium, policy makers and political leaders have turned their attention to innovation-based economic growth. Economic growth is now considered to depend upon a strong knowledge-based system, which rely heavily on production and dissemination of knowledge across institutional boundaries and into use. Recent experience suggests that producing more knowledge does not always translate into economic outcomes in the form of job creation, revenues for firms and economic growth in general.

An increasing reliance on knowledge to spur economic growth in turn brings into focus those institutions and actors which only a few decades ago were considered to be on the fringes of economic activity. With the inclusion of such actors, the concept of innovation system has come to be understood as an "exchange, between actors belonging to different social systems..." (Kaufmann and Tödtling 2001, 793).

These exchanges can be formalized through sales, licenses, contracts, start-ups and, increasingly, partnerships. Partnerships usually involve individuals and organizations from both the public and private domains; hence some analysts term these as Public-Private Partnerships (P3s or PPP). However, these partnerships do not necessarily have to be an amalgamation of

public and private spheres; in many instances they are only between public-public or private-private institutions.

2.1. Research and Technology Transfer Partnerships

The advent of biotechnology along with advances in human genome sequencing and information technology has transformed the face of technology and science in general. Since the 20th century science is perceived as the foundation for economic progress within any nation state or across the global boundaries (Bush 1945). The rapid growth of knowledge-based economies underscores the importance of promoting both basic research and incorporating that research through knowledge transfer from the universities into communities, governments, and businesses (Association of Universities and Colleges of Canada 2008, 1). After the Second World War, science and academic knowledge were positioned as the driving forces behind industrial development and innovation. This move to direct research to practical problems and to translate that research into use gained momentum after the United States adopted the Bayh-Dole Act in 1980, which added commercialization as a mission for publicly funded researchers. Other countries, including Canada, have followed the suit by adopting various strategies to bring academic knowledge to the marketplace.

Universities have been assigned a role within the economic development discourse which had never existed before the biotech and info-tech revolutions. Increasingly, scholars of innovation and technology transfer have started to focus on the university as a key player in the nexus of innovation (e.g. Etzkowitz and Leydesdorff 1999, 2000). One of the reasons for the more central role ascribed to universities and other science-based institutions, is the gradual distancing of governments from providing funding for the production of scientific knowledge.

Universities have increasingly looked to private sector sources to leverage funds for their research enterprise. At the same time, publicly funded universities are increasingly seen as being responsible to the public for ensuring that the funds spent on producing scientific knowledge are ultimately translated into economic growth. Universities are now thought to have a central role, as part of their public responsibility, to aid economic growth within a region. However, that is not to suggest that government or the private sector do not have their own roles to play. Without support from national and regional governments, universities cannot maintain healthy and vibrant research efforts while the private sector is commonly held to be responsible for providing markets for technology being generated in the universities and elsewhere. Therefore, collaboration between these three domains is considered necessary not only for creating scientific knowledge but also for transforming that knowledge into economically and socially valuable uses.

Due to intense pressures imposed by governments, universities feel forced to look for ways to collaborate with the private sector in order to promote economic growth through knowledge production and transformation. Universities are expected to provide the key inputs to innovation and to bring scientific innovations to the marketplace. As a result, a new landscape of public-private partnerships has emerged. As mentioned earlier, the concept of public-private partnerships varies depending on the underlying dynamics by which actors and institutions participate in the process. This can lead to a blurring of organizational mandates in place of clearly defined boundaries. Partnerships can require actors from one sector to adopt characteristics and points of view of actors from the other. Many scholars point to the apparent shift in universities from basic to applied research as a result of their interaction with the industry. Meanwhile, as academics and private sector managers shift their positions within their

respective organizations, attitudes, norms and practices diffuse in the system. Coming to terms with the new reality of research partnerships is a challenging task which requires a more detailed analysis to understand the full effect of public-private partnership.

2.1.1. Defining Technology Transfer Partnerships

The technology transfer or research partnership shares many elements with the classical public-private partnership model. While the concept of P3s is traditionally applied to a collaboration of some sorts between the public and private sectors as well as the non-profit sector in the fields of public infrastructure projects, research partnerships involve an amalgamation of actors and institutions from both the public and private sectors coming together to translate scholarly scientific research into application and use. The primary purpose of such partnerships is to convert scientific innovations generated within academia into commercially-viable products and processes for the markets and economy. Perkmann and Kathryn (2007) suggest that research partnerships are those collaborative arrangements whose primary objective is to achieve cooperation between academia, public sector organizations, and the private sector on research and development activities. Research partnerships therefore represent a distinct type of P3s. The objective function of these partnerships may be different from that of classical P3s instituted for infrastructure projects, where the main task is to replace public management with market norms and processes. Many authors suggest that finding a common space, a set of shared organizational ideologies, and trust are the key ingredients for the research P3 to work. Perceptions (or misperceptions in the case of failed partnerships) and incentives offered to key participants in a research partnership determine the level of success achieved by a partnership.

According to Hall (2006), the concept of public-private partnerships in the context of technology transfer generally involves a set of actors engaged in a multitude of activities

including production, diffusion, adaptation, adoption, and use of knowledge which are brought together to combine existing and new knowledge into a set of marketable technologies, products and services. The system emerging from these interactions between actors from various domains is thought to be governed by the habits, routines, and practices of actors from each of the organizations involved in the process. These interactions often lead to not only product innovations but also process innovations, which are then disseminated across organizational boundaries and into the economy. Such an innovation process leads to interactive learning embedded in an evolving set of relationships and institutional contexts. The evolution of relationships and institutions highlights the fact that knowledge production and diffusion across organizational boundaries are key drivers of economic growth. The key to successful ventures is mobilizing the diversity of stakeholders and institutional rules and norms of the core actors (Hall 2006, 7).

It should be noted here that collaborations between public and private organizations, including academia, rely both on codified scientific knowledge from within the academy and tacit knowledge from other sources (Hall 2006, 7). Codified knowledge emerging from the university might be scientific facts about a particular innovation or invention, but may also encapsulate knowledge emerging from other organizations or departments within a particular organization, for example, knowledge of marketing and business plans generated in a business school within a university. Reliance on knowledge of various forms generated in various contexts underlines the fact that while technical innovations are important, so are process, managerial, institutional and policy innovations (Hall 2006, 8). Innovation thus requires accessing knowledge from a number of different types of knowledge bases. Gaining access to

different types of knowledge bases often involves partnering and other forms of alliances and networking.

In such an environment, knowledge sharing and access is governed by formal agreements and informal institutions, trust, traditions and routines of those involved. Chapter 3 examines this further.

2.2. Models of Technology Transfer and Commercialization

Most of the literature on innovation, specifically technology transfer and commercialization, has focused on context-specific situations. Very few attempts have been made to formalize a framework or a model of innovation that can successfully explain the technology transfer and commercialization process.

Two sets of divergent approaches bound the field. Bozeman's (2000) 'Contingent Effectiveness Model of Technology Transfer' puts forward a paradigm of technology transfer which takes into account the characteristics of the transfer agent, transfer media, transfer object, demand environment and transfer recipient. While the model is useful in understanding the role of each of these factors in determining the success of technology transfer from university-industry collaborations, it is quite a static approach. Etzkowitz and Leydesdorff (2000), on the other hand, have put forward the Triple Helix Model of Innovation which takes into account the dynamic nature of interactions not only between the actors but also between participating organizations. In this model, the interactions between the three helices (university-private-public) lead to a transformation of each of the participating organizations and their actors. These transformations are stored in a new supra-structural layer which shapes further developments in

an innovation system. The Triple Helix allows the analyst to track not only bi-directional interactions but also multiple interactions stored in the new overlay.

2.2.1. Contingent Effectiveness Model of Technology Transfer

Bozeman's model suggests that technology transfer can best be understood in terms of who is doing the transfer, how they are doing it, what is being transferred and to whom (Bozeman 2000, 637). In an attempt to provide a comprehensive understanding of the underlying factors which explain the technology transfer process, Bozeman outlines three competing paradigms prevalent in the technology transfer world. These paradigms extend an understanding of the role assigned to the three pillars (university, public sector and private sector) under different ideological and structural constructs. The market failure paradigm assumes that the primary role of universities is not that of a broker of technology or a commercial competitor but as an educator and a provider of public domain research. The university is, therefore, viewed as the primary source of basic research under this paradigm. In the mission paradigm, the government takes on the role, both directly (through agencies and public labs) and indirectly (through grants to universities), of marshalling resources in order to influence collaborations in such a way as to foster technology development. The cooperative technology paradigm presents a hybrid of the market failure and mission paradigms in that both the university and government play an active role in technology development and transfer. The cooperative paradigm is presented as an overarching system whereby a set of values focusing on cooperation among sectors is advanced. In this regard, the government takes on the coordinating role between the university and the private sector, which can augment productivity and innovation (Bozeman 2000, 631-633).

Bozeman's model identifies five core dimensions: the transfer agent; the transfer media; the transfer object; the demand environment; and the transfer recipient. Characteristics of the

transfer agent can be broadly described by the institutional norms, culture and history of the organization involved in technology transfer (Bozeman 2000, 637). In this context, norms of academia are crucial to understanding the performance of technology transfer activities. In addition, the scope and nature of research activity undertaken by the university as well as the commercial orientation of academics could explain the market impact of technology being commercialized. Other characteristics of the transfer agent that Bozeman deem important for successful technology transfer and commercialization include geographic location, degree of budgetary and managerial flexibility of the projects, the commitment and interaction of the collaborating partners, and the laboratory researcher's familiarity with the firm's needs (Bozeman 2000, 639). These factors, as argued by Bozeman, provide a fundamental understanding of the effectiveness of the technology transfer paradigm.

Transfer media can be understood as the underlying intellectual property policies that are in place at the participating organizations. These policies, as explained earlier, can provide a crucial impetus to transferring a technology from a university laboratory to the private firm. At the same time, however, the very same policies, if not drafted carefully, can hinder the transfer process and result in a failed commercialization attempt. Human capital and training is a fundamental component of the transfer medium. With the increasing complexity of technologies that are produced in academic research labs, providing “know-how” or “tacit knowledge” to the firms by academics can play a key role in successfully commercializing any given technology (Bozeman 2000, 640). It is in this context that the characteristics of the transfer object need to be understood. Much of the performance of commercialization process and collaboration between academia, public and private sector can be explained by analyzing the nature of the product being transferred. Knowledge of product life-cycles, development stages of the technology, and

its adaptability can shed significant light on the effectiveness of the transfer process. Bozeman and many others have argued that much depends on the form (basic research or applied research) and mode (codified, tacit, or explicit knowledge) of a transfer (Bozeman 2000, 642-643).

Understanding the demand environment and the characteristics of the transfer recipient are important determinants in of effective technology transfer. Bozeman has argued that the usual understanding of the demand environment comes from a market-push or a market-pull mentality. However, that may not necessarily be true, as non-market forces often shape demand. In this context, flexibility and critical mass may play a pivotal role in successful commercialization of technology. In addition, the organizational nature of the recipient also determines how a particular technology will be received and subsequently commercialized. The demands and necessities of a firm decide the fate of technologies being produced in the university. Some firms simply want the disembodied technology, product or service; others may be more interested in the technical expertise, resources and knowledge found in the institutions than in the discrete products or licenses themselves (Bozeman 2000, 643-644).

2.2.2. The Triple Helix Model of Innovation

The Triple Helix model is an attempt to capture the dynamics of a complex set of interactions between the three key pillars of an innovation system, namely the university, the public sector and private firms. The model is analogous to DNA, except with a third helix. It adds an extra dimension to the traditional public-private domain by incorporating academia as a key strand. Unlike other models explaining the innovation process, the Triple Helix allows for dynamic interactions within and across the three participating organizations and their actors. The non-linear nature of the model presents the analyst with flexibility to take into consideration

reflexive feedbacks which operate both within and across the boundaries of the participating organizations.

In this model, the system of innovation is thought to be continuously in transition, or what Etzkowtiz and Leydesdorff (2000, 113) have termed as "endless transition." This transitional model gives rise to an overlay of communications and expectations which reshape the institutional arrangements among universities, industries and government agencies. Reformulation of institutional arrangements among the three participating organizations is thought to be a direct consequence of the interactions between the actors from the three spheres, whereby actors from each sphere increasingly takes on each other's roles resulting in a transformation of their own characteristics. The Triple Helix attempts to model these dynamic interactions and the resulting transformations in institutional arrangements and policy models.

The Triple Helix presents different possible resolutions of the relations among the institutional spheres of university, industry, and government which help generate alternative strategies for economic growth and social transformations (Etzkowitz and Leydesdorff 2000, 112). The model has evolved through a number of stages, closely following the economic and political regimes in place. The three evolutionary stages have been termed as Triple Helix I, II, and III. In the Triple Helix I configuration, the nation state oversees academia and industry and is actively engaged in directing the relations between them. This configuration of the model could be found in the former Soviet Union and in East European countries under the influence of communism (Etzkowitz and Leydesdorff 2000, 111). Triple Helix II presents the next evolutionary step. This configuration consists of separate institutional spheres with clearly defined borders dividing them and highly circumscribed relations among the spheres. This is typified by Scandinavian countries such as Sweden (Etzkowitz and Leydesdorff 2000, 112). An

increased focus on tri-lateral initiatives for knowledge-based economic development, however, has transformed the model into what is known as the Triple Helix III configuration, where there are overlapping institutional spheres with each taking the role of the other and giving rise to hybrid organizations at the interfaces (Ibid). The Triple Helix III configuration forms the underlying core of institutional analysis to follow.

The Triple Helix model can be thought of as a network of relationships which generate reflexive sub-dynamics. These sub-dynamics consist of market forces, political power, institutional control, social movements, technological trajectories, and regimes (Ibid). The operations on these sub-dynamics can be expected to be nested and interacting in a dynamic manner. The interaction between these sub-dynamics across the helices can develop an overlay of communications, networks, and organizations. This supra-structural overlay gives rise to a comprehensive innovative system encompassing the creation, dissemination, and utilization of knowledge.

2.2.3. Critique of models of innovation and technology transfer

The Contingent Effectiveness model of Technology Transfer and the Triple Helix model of Innovation have clearly helped extend understanding of the innovation process, as well as understanding of some of the key underlying factors contributing to the effective production, dissemination, and utilization of knowledge. These models present a good starting point for the institutional and behavioural analysis in this paper but both models have their shortcomings which need to be taken into consideration before applying either to the study of technology transfer process and the broader innovation system.

The models are situated at opposite ends of the theoretical spectrum in terms of their dealing with the complexity of the system. Bozeman's model falls short of capturing the dynamism and hence paints an over-simplistic picture of the technology transfer process. In addition, the model extensively focuses on the technical aspects such as the characteristics of the transfer object and consequently ends up ignoring the critical institutional and the role of individuals whose interactions shape up the system. The Etzkowitz-Leydesdorff model, in contrast, represents an extremely complex scenario, with multiple transformations and dynamic interactions taking place simultaneously. At root, the triple helix is closest to an institutional model, but falls short on two accounts. Firstly, it can be argued that more dynamism and complexity is implied in the model than is explained through the proposed theoretical framework. Secondly, it does not provide us with the necessary institutional tools to analyze and explain the interactions and transformations among the three pillars. The model makes no attempt to clarify the underlying institutional grammar that shapes up the interactions among variables within these innovation systems. Moreover, while both models allude to organizational and behavioural factors, neither examines them in depth. Consequently, they leave out finer details which are necessary to understand the functioning of partnerships.

2.3. Rationale for Technology Transfer Partnerships

While the key underlying purpose of a research partnership is production, propagation and transformation of knowledge, not every partnership may be instituted to achieve all of these goals simultaneously. A partnership between university, government, and the private sector may be entered into to achieve only one or some of these goals. In addition, each of the organizations and actors involved in the collaborative process may have their own motivations to participate. It is critical to understand the motivations of each participant organization and their representative

actors in order to get a better understanding of the expected role of the research partnership and its subsequent level of achievement. In this sense, it could be said that research partnerships are context specific and attention must be paid to the underlying goals of each of the partnership. Let us now turn our attention to individual organizations and their motivations in entering a research partnership with other sectors.

Governments are inherently interested in promoting university-industry partnerships because they are thought to contribute towards economic growth of a region. The development of new, high-opportunity technology platforms such as computer science, molecular biology and material sciences based on fundamental university research have prompted a greater focus on establishing university-industry partnerships with government supporting or regulating these partnerships. Such partnerships allow governments to offload some financial responsibilities to the private sector and hence can be viewed as a cost saving or sharing strategy. This way governments can promote basic research, which universities are more able to conduct compared to public laboratories, while at the same time forcing universities to play a more important role in economic growth through technology transfer and commercialization activities.

The reasons a university would want to participate in a research partnership could be two-fold. Firstly, the faculty may be interested in gaining exposure and future employment for graduate students. Research partnerships could present the faculty and university administrators with good opportunities to find placements for their graduates in the private sector. These partnerships also present an opportunity for the university researchers to bring their research into the marketplace and gain recognition for their basic research. In order to achieve this goal, many faculty members offer their services to the private sector through consultation in addition to direct collaborations with industry to develop products suitable for the market. Through

networking with private sector managers and entrepreneurs, academic researchers may also engage in learning about the market structures and the demands of the markets. This, in turn, may lead to new ideas and enable the researcher to incorporate these ideas into their research programs, sometimes generating products more suitable for commercial purposes. These partnerships also present faculty with opportunities to leverage private sector funding to expand their research programs. Declining financial support from government has in many cases created a need to find new financial sources in order to be able to carry on with basic research. Research partnerships, in whatever form they may be, can provide the faculty with financial rewards, which can then be invested into lab equipment and hiring more students. All these activities translate into more research productivity for the faculty involved, allowing them to progress in their academic careers.

Private sector firms are also interested in partnering with academia and the public sector for a variety of reasons. Firstly, collaborating with universities allows firms to make use of state-of-the-art research equipment, which at times only universities have access to. Firms, especially smaller ones, may not have the capacity to conduct in-house R&D and acquiring such capacity may not be financially viable. Therefore, firms often turn to universities to gain timely and cost-effective access to specialized equipment. Secondly, and more importantly, collaborating with universities allows firms of all sizes to tap into a vast base of academic knowledge, tacit knowledge, and know-how knowledge, which only academic researchers may possess. It has been pointed out that larger firms are "less interested in proof of concept or reduced to practice stage technologies because of internal rate-of-return requirements on R&D investments" (Markman et al. 2005, 252). For such large and resource-rich organizations, access to know-how and tacit knowledge is more important. Crossing organizational boundaries and entering into

partnerships with academia therefore allows the firms to engage in an interactive learning process and help firms to introduce not only technological innovations, but also organizational innovations (Kaufmann and Tödtling 2001, 791) These organizational innovations, as argued in the innovation literature, are an important component to a firm`s success and survival in the long run.

2.4. Key Elements of Technology Transfer Partnerships

A review of literature on research partnerships suggests a variety of elements that may be necessary in forming a research alliance between university and the private sector. Generally speaking, firm-industry research partnerships rely upon formal and informal interactions which are influenced by firm strategy and industry characteristics, university policies, the structure of the technology transfer operations and regulatory parameters defined by government policies (Bercovitz and Feldmann 2006, 177). Many of the elements deemed necessary in a research partnership are the ones which are also thought to be crucial in developing a conventional public-private partnership. For example, presence of a common ideological space and synergies between the academic and the private sectors is a key factor needed for a research partnership to form. A research partnership ought to enable participating organizations to share risks, build on jointly shared capabilities, and create synergies for better competitiveness (Santoro and Gopalakrishnan 2001, 163). In addition, the parties to such partnerships ought to collaborate to further mutually compatible interests rather than to act opportunistically. Therefore, finding complementarities is the first step towards establishing a successful research partnership and realizing the proposed goals of that partnership.

Similarly, trust and favourable perceptions of the participating actors are crucial factors for the successful development of research partnerships. Santoro and Gopalakrishnan (2001) argue that trust building serves to promote partnership development on three fronts. Firstly, trust building allows collaborating organizations to develop confidence about their partner's abilities and expected behaviour. Secondly, trust leads an organization to cooperate rather than be sceptical of the other organization. Finally, trust serves as a social control mechanism that helps govern economic transactions (Santoro and Gopalakrishnan 2001, 165). In a similar attempt, Harmon et al. (1997) have suggested that respect and trust, along with open communication, mutual interdependence, and willingness to compromise are factors which can greatly facilitate the partnership building process. Open communication is considered important in this regard, as it can help in building higher trust levels as well as allowing the partners in searching for synergies within the partnership (Harmon et al. 1997, 426).

From the administrative point of view, it has been argued that, intellectual property rights (IPR) are the key mechanism which can facilitate the exchanges of technology and knowledge between academia and private sector. IPRs are considered very crucial in determining private sector perceptions about the university they plan to collaborate with. IPRs thus act as institutional incentives for the private firms, as they determine the viability and accessibility of a certain technology for the private sector. Flexible IPR regimes are considered extremely important to get a favourable perception by private sector. Santoro and Gopalakrishnan (2001) have argued that when universities give up sole ownership of IPRs, patents, and licenses, it projects the university as a flexible and motivated partner in the view of private firms. In addition, by rewarding potential partners the university demonstrates to the industrial community that industry alliances are valued (Santoro and Gopalakrishnan 2001, 166). The literature also

suggests that IP ownership is a key signal to the private sector about the availability of certain technology and knowledge that is ready to be transferred to the markets. Siegel and Wright (2007) argue that a critical mass of IPR in a focused number of areas is an important part of developing a university commercialization strategy. IPRs act as a signal to the private sector that a university has the necessary skills, capabilities, and willingness to collaborate with the private sector to commercialize technology (Siegel and Wright 2007, 535). At the same time, Siegel and Wright stress the importance of maintaining a balance between intellectual property (IP) ownership and flexibility. It has been suggested that an aggressive IP policy on part of the university can spark a competitive rift between the university and the private sector, which could impede development of a partnership between the two sectors. Nevertheless, IPRs are a crucial determinant of the viability of a research partnership and therefore should be analyzed carefully within the context of research partnerships.

While in-house IP policies governing the interactions between the two sectors are important, spatial theorists have posited that geographic proximity between the university and the private sector firms is also an important factor. Santoro and Gopalakrishnan (2001) have argued that the greater the geographic proximity between the industrial firm and the university research center, the greater the potential for technology transfer. Geographic proximity facilitates the natural exchange of ideas between the university and the private sector through both formal and informal exchanges. The line of argument suggests that due to the nature of interaction between the university and firms, capturing knowledge spill overs is a main concern for the private sector firms. Being located within a close proximity to the university allows them to capture these spill-overs and the associated benefits at relatively low cost (Santoro and Gopalakrishnan 2001, 165).

Lidelof and Lofsten (2004) have shown in their work that firms, especially newly formed technology based firms (NTBFs), located in close proximity to a university have networking advantages which can be a huge value to the newly established firms (Lindelof and Lofsten 2004, 311). These firms usually lack the scale and scope to conduct in-house research--geographic proximity to the university research center provides them access to the faculty, laboratories and employees in the form of graduates. Spatial proximity, therefore, increases the competitive advantage of a firm engaged in a research partnership with the university. In addition to any benefits of geographic proximity for industrial firms, the university itself can tap into complementary assets in firms, such as manufacturing, distribution, and marketing, in order to support research, train staff and to commercialize products generated within the university. Lindelof and Lofsten (2004, 314) show that organizations established in a close proximity can generate high levels of wealth and jobs.

Another crucial element in developing effective research partnerships between universities and private firms is the level of willingness and capabilities of the faculty members to engage in the technology transfer process. The literature on technology transfer suggests that faculty researchers at academic institutions are a key stakeholder in a research partnership. Bercovitz and Feldmann (2006) argue that the role assumed by the individual faculty member is at the heart of technology transfer process (Bercovitz and Feldmann 2006, 180). A willingness on part of these scientists to engage in the partnership process can greatly enhance the effectiveness of a research partnership and related commercialization.

Zucker, Darby and Armstrong (2002) have intensively studied the relationship between the presence of “star scientists” and their impact on the research partnerships. The level of interaction between star academic scientists and private sector scientists is shown to have a

significantly positive impact on the levels of technology transfer and a firm's innovativeness (Zucker, Darby, and Armstrong 2002, 139). The authors argue that self-interested participation by key professors is an essential condition for successful commercial licensing of university inventions (Ibid). They argue that university scientists bring with them a source of tacit knowledge which is essential for the further development, adaption, and commercialization of technology and products generated in university laboratories. Therefore, a strong entrepreneurial ethos at the individual faculty level is a necessary element in the development of university-industry research partnerships.

Different institutional factors affect the motivation of individual faculty members to engage in the technology transfer process. It has been argued that an individual faculty member's decision to participate in the technology transfer process is influenced by three factors: training effects, leadership effects, and cohort effects (Bercovitz and Feldmann 2006, 180). Thursby and Thursby (2002) have argued that underlying the motivations of individual faculty members are the ideological beliefs of these researchers about the nature and role of their research (Thursby 2002, 92). University scientists are not just motivated by money—their individual cognitive processes influence their interest. The impact of individual cognitive positioning on the development and success of research partnerships will be dealt with in the fourth chapter.

2.5. Typologies of Technology Transfer Partnerships

The literature highlights many forms of research partnerships, categorized based on their function, institutional rules or actors involved. Regardless of the specific form a partnership takes, the key element in any research partnership is the production and dissemination of knowledge. As mentioned in the previous sections, this could be institutional, know-how, or tacit

knowledge held by a multitude of actors in participating organizations. Specific forms of research partnerships may be preferred over others because they guarantee a better diffusion of knowledge (Bonaccorsi and Piccaluga 1994, 236). Dooley and Kirk have classified research partnership in an order of increasing depth of relationships between the partners and the duration of the interactions. According to their classification, research contracts or grants falls at the bottom end of the spectrum while cooperative research is most enduring in terms of intensity and length of partnership. Technology transfer, followed by knowledge transfer fall in the middle of the spectrum (Dooley and Kirk 2007, 319). It is interesting to note that this classification ranks knowledge transfer higher than technology transfer in terms of the length and intensity of relationship between the two sectors. Perkman and Walsh (2007) have also provided a typology based around the relational involvement (table 2.1).

Table 2.1. A typology of university-industry links

Extent of relational involvement		
High: relationships	Medium: mobility	Low: transfer
Research partnerships Research services	Academic entrepreneurship Human resource transfer	Commercialization of IP (e.g. licensing)
Use of scientific publications, conferences and networking (can accompany all forms)		

Source: Perkmann and Walsh 2007, 263.

Based on the IP structure and policy adopted by the university, Markman et al. (2005) argue that universities can transfer their technology through different strategies. These strategies include licensing in exchange for sponsored research, licensing for equity in a company or licensing for cash (Markman et al. 2005, 242). The firm willing to enter in a partnership with the

university would prefer one of these methodologies depending on the stage of technology, which the authors classify as early-stage inventions, proof of concept, reduction to practice, and prototyping. Based on an empirical study conducted in United States, they established a correlation between stages of technology development and various technology transfer strategies (e.g. sponsored research, equity, and cash) as well as the recipients of these technologies. Figure 2.1 captures these relationships.

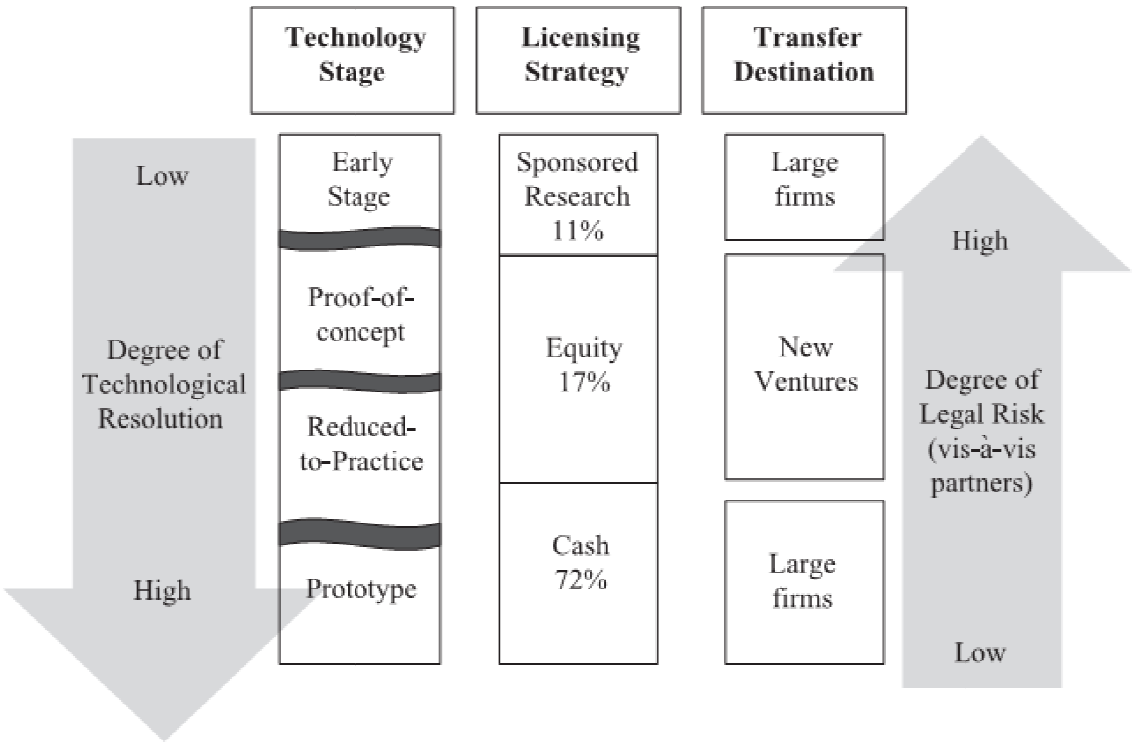

Figure 2.1. The relationship between technology stage, licensing strategy, and transfer partner
Source: Markman et al. 2005, 257.

Bercovitz and Feldmann (2006) have classified different forms of research partnerships based on the formalization or lack thereof of transactional mechanisms adopted by the partnering

organizations. They argue that "firm-industry interactions combine formal and informal interactions and are influenced by firm strategy and industry characteristics, university policies as well as the structure of the technology transfer operations and the parameters defined by government policy" (Bercovitz and Feldmann 2006, 177). These factors in turn influence the nature of a specific partnership, which can take the form of sponsored research, licenses, hiring of students, and spin-off firms. These basic forms of partnerships are then often complemented by activities such as consultation by individual faculty members, participation in research consortia, conferences and other informal networking events. These complementary activities ensure that the transfer of technology and knowledge is bidirectional— that is, it flows both to and from the university and the firm.

2.6. Role and Structure of Technology Transfer Offices in P3s

The technology transfer office has a key role to play in the technology transfer and commercialization process. Depending on the structure and mandate instituted for the technology transfer office by the university administration, the technology transfer office may engage in a series of activities including networking with potential partners, patenting and licensing technology, and assisting and actively participating in spin-off creation. This list of activities is not exhaustive by any means. The technology transfer office may engage in either one or a combination of these and many more activities. In short, the technology transfer office has a complex set of tasks that it undertakes at various junctures of technology development, transfer, and commercialization.

Various authors define the role of the technology transfer office as 'intermediary', 'facilitator', and 'guardian'. The TTO may undertake these roles simultaneously or switch

between these at different stages of the transfer process. Siegel, Veugelers and Wright (2007) argue that the technology transfer's primary role is that of an intermediary between suppliers of innovations (i.e. university scientists) and those who can potentially commercialize them (i.e. private sector firms, entrepreneurs, and venture capitalists) (Siegel, Veugelers, and Wright 2007, 641). By acting as an intermediary, the technology transfer office facilitates commercial knowledge transfers of IP from the university either through licensing to existing firms or via start-up companies (ibid). In this context the technology transfer office also acts to reduce institutional and technological uncertainty between the two parties. It fills any voids that exist between knowledge generation and transfer, effectively engaging in a balancing act during negotiations with private firms (Siegel, Veugelers, and Wright 2007, 643).

Another line of argument taken by Siegel et al. (2004) is that technology transfer offices view themselves as the guardians of a university's IP portfolio. In this context, the primary motive of the technology transfer office is not only to safeguard the university's intellectual property portfolio but also to market that technology in a way that is most profitable for the university (Siegel et al. 2004, 118).

The effectiveness of a technology transfer office's activities depends to a certain extent on its organizational structure. Debackere and Veugelers (2005) have argued that universities with a decentralized technology transfer process, through a dedicated and specialized set of technology transfer offices, often deliver the greatest number of successful research partnerships and technology commercialization (Debackere and Veugelers 2005, 323). In contrast, if a university opts for a professional bureaucracy, marked by traditional faculty and departmental organizational boundaries and structures, the university's commercial orientation is likely to be limited. Divisional structures may be used to discern an institution's intent towards commercial

exploitation—decentralized approaches and incentive mechanisms are required to engage and to involve the researchers and their groups as active partners in the exploitation process (Debackere and Veugelers 2005, 324).

Markman et al. (2005) argue that technology transfer offices can be classified into three archetypes: university structures; non-profit 501(C)1 research foundations; and for-profit private venture extensions (Markman et al. 2005, 242).[1] Non-profit research foundations [501(C)1] enjoy more flexibility than the traditionally structured TTO in terms of granting compensation and incentives to personnel, with pay levels that can sometimes exceed the university grade system (Markman et al. 2005, 243). Private venture extensions were most aggressive at creating start-ups and raising capital (Ibid). Of the three TTO archetypes, the for-profit private venture extension is best positioned to accelerate new business formation (Markman et al. 2005, 259).

Siegel, Veugelers and Wright (2007) have put forward a classification of technology transfer offices based on their organizational structure. They argue that technology transfer offices can be classified into four distinct organizational forms: the functional or unitary form (U-form), the multidivisional form (M-form), the holding company form (H-form), and the matrix form (MX-form). The authors argue that these structures have different impacts on a university's ability to coordinate activity, facilitate internal and external information flows and align incentives in a manner consistent with its strategic technology transfer goals (Siegel, Veugelers, and Wright 2007, 641).

[1] This typology refers to the structures in United States. For more information, refer to (Markman et al. 2005, 248). The authors have provided a description of these structures along with their key features, advantages, and examples.

Based on the Siegel-Veugelers-Wright (2007) classification of technology transfer offices, Debackere and Veugelers (2005) argue that the matrix structure allows research groups to be actively involved and engaged in the commercial exploitation of their own research findings. In a matrix structure, the division of research exploitation indeed becomes decentralized and integrated within research groups themselves. Only a minimal central technical support infrastructure remains to assist the decentralized divisional structure(s) with issues like intellectual property management, contract drafting and negotiation, and business plan development for spin-offs.

The matrix structure is a commercially oriented approach, usually involving commitments of resources to commercialize research findings, efforts to capitalize on scale economies in supporting services, and direct incentives to researchers and their groups to participate in the process. In a matrix structure, accountability (both with respect to revenue and expense generation) is located at the level of the research group, which should act as a direct incentive for the researchers themselves to actively manage and grow their portfolio of explorative and exploitative research activities (Debackere and Veugelers 2005, 329). A matrix structure, integrating but yet differentiating exploitation and curiosity-driven academic exploration, through a network of research divisions and coordinators, is offered as a structure that should allow a university to advance scientific discovery and techno-scientific innovation (Debackere and Veugelers 2005, 338).

2.7. Impediments in Technology Transfer Partnerships

Like conventional public-private partnerships, research partnerships can stumble across obstacles which hinder their development. Some of the most well documented problems include:

the “two culture” problem; uncertainty around viability of the technology; and rigid IP structures. While these are commonly cited problems, others can hinder the development of research partnerships. Some impediments contemplated by Perez and Sanchez (2003) include lack of financial resources, small size of market, excessive risk, lack of information on market features, lack of time, lack of information on potential business partners, lack of information on know-how, and lack of trust among partners (Perez and Sanchez 2003, 824-825). A selection of these factors and how they can hinder the technology transfer process are examined in this section.

2.7.1. Different Cultures

One of the most cited impediments in the process of effective partnership development is the differing ‘cultures’ of the participating organizations. It has been argued numerous times in the literature that differing cultures of the participating organizations can impede success. Siegel at al. (2004) in their work on technology commercialization have found significant differences in cultures across the participating organizations that can significantly hinder the technology transfer and commercialization process (Siegel et al. 2004, 125).

The term ‘culture’ is often used to describe the practices, norms, and rules that exist within an organization. One needs to understand that universities and the private sector have different sets of organizational practices. These differences arise as a result of different motives, perspectives, and ideological beliefs held by participants in each sector regarding the role of research in society. Traditionally, the role of university has been in creating and disseminating basic scientific knowledge into the society—the academy has come to regard knowledge as a public good which should be freely available to all. Accordingly, university researchers consider

that it is their duty to make public knowledge generated through their research, most often through publishing in peer-reviewed journals.

The private sector is governed by a different set of motivations and perspectives about the nature of technology and knowledge in general. Private firms are mostly motivated by pursuit of profits and competitive advantage over commercial rivals. As a result, knowledge is usually held confidential and strictly as a private good. Private firms often conduct research in order to extend their existing product line or improve those products by introducing process or product innovations, which are designed to yield higher profits for the firm. The challenge then is the conflicting desire of academia to publish and industry to maintain secrecy to secure intellectual property rights and maintain competitive advantage (Dooley and Kirk 2007, 325).

The stark disparities in the motives, perspectives, and cultures of the three key players in this process underscore the potential importance of understanding how organizational factors and institutional policies influence the development of effective research partnerships between academia and the private sector (Siegel and Veugelers, Reinhilde ,Wright, Mike 2007, 651). Lee has referred to this phenomenon as the 'Two Cultures Problem, ' suggesting that the normative and attitudinal differences separating universities from industry are inexorable and present often insurmountable barriers to close cooperation between the two sectors (Lee 1996, 856).

Differences in the objectives and operational standards across the two sectors can give rise to conflicts (Bonaccorsi and Piccaluga 1994, 232). The conflicts are further exacerbated due to a lack of effective communication between the two sectors. There is often a mismatch of information, knowledge, vocabulary, conception or services needed by industry and offered by university. When there is a lack of understanding of each other's 'culture' due to poor

communication, it gives rise to conflict of interest especially over dissemination of knowledge versus its appropriation through commercialization, which in turn hampers the technology transfer and commercialization process.

Bonaccorsi and Piccaluga (1994) have argued that in university-industry relations both parties hold strong but heterogeneous bases of power: universities hold strong expert power, while companies may have a combination of reward and expert power (Bonaccorsi and Piccaluga 1994, 235). Any resulting partnership will often be biased towards the stronger partner, which also will need to shoulder greater responsibility due to a stronger position within the relationship. These asymmetries in mutual dependence result in an increased perception of vulnerability among the other partners and reduce the propensity to open and effective collaboration (Bonaccorsi and Piccaluga 1994, 237).

Universities and the private sector represent two distinct "thought worlds", with distinct languages and organizational routines. Coming to terms with these "thought worlds" is a challenge for those seek to participating in a research partnership. Communication failures exacerbate the problem further, which leads to misunderstandings and a general lack of trust among partners (Bercovitz and Feldmann 2006, 178).

2.7.2. Uncertainty

Technology transfer scholars have often pointed towards uncertainty as an important challenge. Uncertainty can arise through multiple channels in the technology transfer context. The most common of these is technical and commercial uncertainty surrounding certain types of innovative activity, such as the application and value of basic research (Siegel and Wright 2007, 537). The very nature of partnerships which rely on creation and dissemination of new

knowledge lies at the heart of such uncertainty. According to Debackere and Veugelers (2005), the highly non-codifiable nature of scientific know-how results in high levels of uncertainty around the commercial viability of a particular invention. This uncertainty in turn can lead to systemic failures in the market for know-how, thus explaining the difficulty of organizing research partnerships, specifically those instituted for technology commercialization (Debackere and Veugelers 2005, 338).

Siegel, Veugelers, and Wright (2007) argue that due to the large uncertainty surrounding the nature and value of new knowledge, firms typically cannot assess the quality of an invention ex ante, at least partly because the invention often is in an embryonic stage of development. Meanwhile researchers find it difficult to assess the commercial profitability of their inventions. Uncertainty is higher with early stage inventions which make them a riskier prospect for commercialization. Private sector managers are typically focused on risk-adjusted returns and the highly risky nature of university research reduces the projected private rates of return. As a result, managers take a more cautious approach towards these technologies. Significant informational asymmetries and uncertainties regarding the potential markets for innovations can complicate efforts to collaborate with universities (Siegel and Veugelers, Reinhilde ,Wright, Mike 2007, 645).

Markman et al. (2005) have classified uncertainty around technology transfer and commercialization into two continuums. They suggest that uncertainty could arise as a result of ambiguity regarding whether a particular technology has market application and ambiguity regarding the robustness of the legal protection over the IP (Markman et al. 2005, 252). These uncertainties are not mutually exclusive; as a matter of fact they could very well reinforce each other at different levels.

2.7.3. IP Policies

While there is significant disagreement over the exact impact of intellectual property policies, there is evidence that these policies can have a significant impact on the development of effective research partnerships. There are multiple challenges that IP policies can pose in the technology transfer process. The presence or absence of IP policies can provide a good signal to the firm about the technological capacity of the university. In this regard, the technology transfer office within the university has a major role to play.

University administration can play a key role in setting the direction of IP policies. The direct, and often strong, oversight by a university administration limits the autonomy of technology transfer office management in matters of decision making, licensing strategies, and incentive systems (Markman et al. 2005, 243). In those cases where the university sets the direction of the IP policy, there is a tendency within university management to get very aggressive about exercising intellectual property rights (Siegel et al. 2004, 118). It has been further argued that vague rules regarding the ownership of IP within the university itself can create significant distortions in the commercialization process. The IP may not be owned by the academic inventor but by the university, creating issues relating to its exploitation through a spin-out (Wright, Birley, and Mosey 2004, 241).

Another potential hindrance comes through the general outlook of the university administration towards the potential utilization of university owned IPRs. University and the technology transfer offices that project a risk-averse attitude towards commercialization tend to be more focused on converting IPRs to cash through licensing. As a result, their focus shifts from establishing long-term relationships with industry towards shorter-term relationships generate

cash flow. These attitudes and policies can severely damage the potential from long-term well established relationships with the private sector, leading to sub-optimal commercialization.

The division of revenue amongst the parties is often an area of rousing debate among collaborators. Disagreements are common in this area, with industry claiming that IP from universities is often over-priced and ignores the risks industry is exposed through the commercialisation process. Universities fear that industry may steal their discoveries and generate and appropriate revenue streams that rightly belong to the university. Only through defined processes and trust can this challenge be overcome (Dooley and Kirk 2007, 320).

As a result of these policy rigidities, firms can have great difficulty in dealing with universities on IP issues. It has been reported in the literature that a firm's first dealings with university technology transfer office in regards to IP issues usually sets the direction for further dealings and collaborations. If an initial experience with the university technology transfer office is negative, firms may tend to engage in opportunistic behaviour by contracting directly with faculty members, bypassing the university intellectual property apparatus (Bercovitz and Feldmann 2006, 178).

One final notable shortcoming in the operation of most IP systems relates to difficulties in enforcing IPRs. Problems can include the high cost of enforcement, sub-optimal regulation, conflicting priorities in tackling IPR infringements, and piracy and counterfeiting where copying and distribution is facilitated by digitization and the internet. Litigation costs seem to be especially problematic (Siegel and Wright 2007, 536).

2.7.4. Bureaucratic and Administrative Procedures

Bureaucratic procedures appear to present another source of barriers in the technology transfer process. As mentioned earlier, universities tend to engage in strong oversight of the technology transfer process. In many cases the technology transfer office reports to the senior university administration, which adds a multitude of complex bureaucratic procedures to the process. As a result, the technology transfer office can find itself in situations where its capacity to respond quickly to emerging technological inventions is severely constrained.

Another problem highlighted by Siegel, Veugelers and Wright (2007) and Siegel et al. (2004) is the staffing and compensation practices in many technology transfer offices (Siegel, Veugelers, and Wright 2007; Siegel et al. 2004). Technology transfer offices are reported to have insufficient resources allocated to them, which limits their ability to hire personnel with appropriate skills and experience. As a result, technology transfer offices often are poorly resourced for carrying out the proper procedures necessary for the commercialization of technology. As for compensation, one can look at the general differences between university and public sector compensation practices. Incentives are rare for public sector inventors and, which universities are more amenable to providing incentives for their researchers they are often much less and very limited compared to the private sector.

2.7.5. Faculty Attitudes

Faculty members and university researchers who produce technological inventions and other academic knowledge have a significant role in the technology transfer and commercialization process. Academic researchers can and often do play a role beyond the invention stage due to the rich know-how knowledge that they carry with them. However, it is

important to understand how faculty attitudes may be at play in the commercialization of specific technologies. Older generation faculty members are frequently cited as being more averse to the idea of turning academic science into potential revenue-generating avenues. The reason behind this is the "public good" mentality usually associated with academic science and knowledge. Younger and newer faculty are reportedly more favourable to university technology commercialization and partnerships with the private sector, partly in response to the new economic development mission of the academy and partly in response to limited government funding for university research. Nevertheless, there is still a lot of scepticism within academia about the role of private sector in commercializing university generated technologies.

The "two cultures" problem contributes to this sceptical attitude, as the faculty at times misperceives the motives of the private sector. The common perception of partnerships with the private sector in academic circles is that they can and at times do jeopardize academic freedom. It is a widely held notion that these partnerships convert the academic tradition to what some scholars have termed "academic capitalism," which they fear may jeopardize their right to disseminate knowledge freely to the public. Furthermore, some fear increased private sector influence in academia could significantly shift the focus of research from upstream basic research to more applied downstream research, which many would argue end up degrading the quality of research conducted at the university. This argument is usually put forward by those followers of the concept of an "intellectual hierarchy" which considers applied science to be second class outcome to basic research (Lee 1996, 847).

Another factor which negatively affects faculty attitudes is the often misaligned compensation practices in some partnerships. Traditionally, publishing articles has been a good indicator of faculty career achievement. However, entering into partnerships with the private

sector or leading a start-up firm can at times restrict or delay faculty from publishing. Part of this barrier arises due to time commitments that are required to make a partnership successful, which discourages some faculty members from devoting much time and attention to any partnership opportunities that would keep them from getting their results published. Moreover, compensation systems in universities often do not recognize faculty roles in commercial development of technology. As a result, faculty may find few, if any, incentives to participate in a research partnership. Lack of incentive structures, including both pecuniary and non-pecuniary rewards such as salary increases, tenure, and promotion diminish faculty interest in contributing towards building research partnerships with the private sector or to commercialize inventions (Siegel and Veugelers, Reinhilde ,Wright, Mike 2007, 645). In those cases where a faculty member does participate in the process, he or she usually has to bypass university norms and forgo normal compensation routes, searching for benefits through extra-university compensation.

Faculty attitudes are frequently a function of the general entrepreneurial orientation of the institution. While some entrepreneurial skills can be acquired through involvement and experience dealing with commercialization of technologies, a large part of the entrepreneurial culture is cognitive in nature and is viewed as hardwired into individuals. The behavioural underpinnings of faculty attitudes towards commercialization decisions are addressed in greater detail in chapter four.

2.8. Conclusions

The literature helps us understand the basic conceptions of public-private partnerships as they apply to technology transfer and commercialization partnerships. This chapter has presented an extensive survey of the literature on partnerships that helps us understand the key features of

technology transfer partnerships as well as some of the impediments commonly faced within these partnerships. Organizational cultures, IP policies, faculty attitudes and administrative procedures are key factors which seem to play a decisive role in determining the efficacy of these partnerships. However, most studies focus on just one of these factors at a time. This Furthermore, many studies narrowly concentrate on one or two specific cases, without effectively developing a comprehensive analytical framework. None of the works reviewed here delve into the institutional and behavioural underpinnings of these partnerships. The next two chapters undertake that task.

Three

Institutional Analysis of Technology Transfer Partnerships: An IAD Framework Approach

The previous chapter highlighted some of the concepts found in the literature regarding the technology transfer process and the role of partnerships. Those studies are valuable in that they provide an understanding of some of the fundamental issues dealing with research partnerships developed to promote technology transfer. However, one problem is that they take a very contextual approach. While some attempts have been made to develop a generalized theory of technology transfer and innovation processes, they have been less than successful in explaining reality. Models such as the contingent effectiveness model of technology transfer are too simplistic, often focusing on technical aspects such as intellectual property rights and consequently failing to capture the complexity of the entire process. While more dynamic models such as the Triple Helix are closer to the institutional reality, their design implies more dynamism than can be explained within the confines of those institutional structures. In other words, the Triple Helix model fails to specify the institutional tools that can help us unpack the complexity of technology transfer partnerships or the broader innovation systems.. Missing from these models and the larger cannon of literature on technology transfer partnerships is an

institutional formalization of various aspects of technology transfer processes. Without formalizing the organizational interactions and individual motivations, which are at the heart of any innovative process, it is not possible to understand the dynamics of technology transfer.

This chapter adapts an institutional approach to the analysis of technology transfer partnerships, in order to provide a systematic approach to enable the reader to capture the underlying dynamics of the technology transfer and commercialization process. This paper uses the Institutional Analysis and Development (IAD) framework as the foundational building block of analysis. This particular approach offers the opportunity to capture both static and dynamic interactions in a complex innovation system. As shown below, the IAD framework has the capacity to decompose a complex system into its constituent sub-systems and allow the analyst to focus on one particular aspect, in this case the dynamics of technology transfer partnerships, which are essentially a sub-systemic component of the broader innovation system.

An institutional approach using IAD is preferred over more traditional economic models such as principal-agent theory for two primary reasons. Firstly, the principal-agent theory does not account for the horizontal nature of such complex systems where vertical lines of authority are difficult to establish. It may be helpful in understanding intra-organizational situations such as the university-technology transfer office-researcher relationship, but it fails to capture the dynamism of cross-organizational initiatives where participants belong to different organizations. Secondly, traditional economic models fail to capture the cognitive limitations of individual participants who shape these systems. As we show in chapter four, assumptions of comprehensive rationality do not hold across many complex situations and that is where traditional models of economic incentives usually fail to explain the interactions between individuals who participate in these systems.

This chapter has three main sections: the institutional theories and their critiques; a brief overview of the IAD framework; and an exercise to map the technology transfer process using the framework.

3.1. Defining Institutions- Conceptual Clarifications

There are multiple views held by theorists about the defining elements of institutions, as well as their role in different systems. The most commonly held view that has informed a great deal of analysis to date is that of economic institutionalism. The classical economic theory posits that institutions do not matter much in establishing a market structure (North 1993, 1). However, recent works tend to disagree with this notion. Douglass North, in his seminal work on institutionalism and neo-classical economics, has argued that "institutions form the incentive structure of a society and the political and economic institutions, in consequence, are the underlying determinant of economic performance" (ibid). According to North, institutions are the humanly devised constraints that structure human interaction. These can be divided into formal and informal constraints--formal constraints consist of rules, laws, and constitutions, whereas informal constraints are comprised of norms of behaviour, conventions, and self-imposed codes of conduct. Together with enforcement characteristics, these constraints define the incentive structure of societies and economies (North 1993, 2). Institutions are extremely important for understanding inefficient markets where the transaction costs have the tendency to outweigh other benefits that can be garnered through market interactions.

While North (1981, 1993) has put forward the economic rationale of institutions, others have formulated divergent conceptions of institutions. Schotter (1981), for example, argues that the main function of institutions is that of information organizers. According to this view,

institutions reduce uncertainty by translating past experiences into institutional rules which then become a guide for future expectations. The more institutions encode expectations, the more they reduce uncertainty and solve problems which arise from boundedly rational behaviour of individual actors (Edquist and Johnson 2005, 43). Therefore, the information organization role of institutions plays a vital role in the economic, political, and social setup that surrounds us.

Edquist and Johnson (2005) have suggested a broad definition of institutions by combining the different elements of institutional theories that have been put forward previously. They define institutions as sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals and groups (Edquist and Johnson 2005, 46). Based on this definition, the authors develop a multidimensional taxonomical classification of institutions. This taxonomy relies on the differences between formal and informal institutions, hard and soft institutions, as well as basic and supporting institutions. Both basic and supporting institutions can be formal or informal as well as hard or soft. Such taxonomy allows one to use the combination that fits the context most appropriately.

Despite the work done by institutional theorists, there is still a great deal of confusion around the concept of institution, at least partly as a result of lack of clear institutional grammar. For example, the concept of rules and norms as they relate to institutions is used interchangeably in extremely varied contexts. Similarly, one can commonly find a conflation of the terms institutions versus organizations. The use of these terms is commonly misplaced in the literature. It is only recently that institutional theorists have started to acknowledge these problems. Ostrom (2005) has highlighted both these issues in her work on developing the Institutional Analysis and Development (IAD) framework. The underlying components of the IAD and how they apply to technology transfer partnerships is addressed below. Before delving into institutional analysis, it

is important to situate the innovation systems and their components within the broader institutional literature.

3.1.1. Innovation Systems and Institutions

In addition to laying down a classification of institutions, Edquist and Johnson have applied the concept of institutions to innovation systems. They argue that institutions affect the innovation process by shaping the interactive learning process between individuals. In the context of innovation systems, institutions perform three basic functions: reduce uncertainty by providing information; manage conflicts and cooperation; and provide incentives. As shown in the previous chapter, uncertainty, conflicts, and lack of incentives are the main barriers to innovation and technology transfer. Institutions can reduce, if not eliminate, these barriers and aid the innovation processes.

The very nature of innovation and technology transfer processes introduces a great deal of uncertainty into the system. When it comes to research partnerships, the partners are uncertain about future expectations—they seldom know whether or not a technology will prove profitable when introduced into the market. In the absence of governing institutional mechanisms such as patent laws or other intellectual property rights, uncertainty over the ability to appropriate returns on technology can discourage stakeholders from entering into partnerships. Institutional structures are therefore a necessity when it comes to establishing effective technology transfer partnerships. While uncertainty cannot be completely eliminated, it can be reduced by providing pertinent information to the actors involved in a research partnership.

In the case of research partnerships where stakeholders frequently do not have much experience dealing with each other, there is always a potential that conflicts could arise between

the participants. Having well established institutions in these cases can help participants overcome insecurities. In such circumstances, institutions can spell out the constraints and boundaries for each actor . In addition, institutions can define the power structures within a research partnership by establishing clear responsibilities for participants. When, in reality or in the perception of participants, there is a mis-calibration of power structures, institutions can also help realign these power imbalances.

Institutions can further provide incentives to the participants in partnerships. It has been argued that incentives provided to individual faculty members can provide a key motivation to engage in entrepreneurial activities. Institutions can facilitate partnerships by targeting the incentives towards the specific requirements of individual participants depending on their organizational affiliation. Therefore, the incentives offered to a university scientist can differ substantially from those offered to a public sector researcher or to a private sector manager. Incentives can also be negative in nature. In other words, they can constrain certain behaviours by outlining the consequences (penalties) of engaging in such behaviours.

As highlighted, institutions can facilitate the process of establishing research partnership by governing aspects of information, uncertainty, pecuniary and non-pecuniary incentives, and conflict management. Many other factors, which will be dealt with in the following sections, can make the technology transfer process more efficient. In order to carefully assess which institutional factors affect the technology transfer partnerships, one can follow the IAD framework and map out the various components of this framework onto the technology transfer partnerships.

3.2. The Institutional Analysis and Development (IAD) Framework

The IAD has been put forward as an attempt to explain the institutional underpinnings of many of the complex problems faced in today's world. The intention behind developing such a framework was to coherently and comprehensively deconstruct the complexly nested layers of organizational environment, actors, rules, and the anticipated outcomes. The focus of this framework is not just on the organizational structures; it also unfolds the complex layers of interactions between actors and the organizational codes as well as interactions among the actors themselves. It highlights the behavioural underpinnings of many of the problems and the complex solutions that emerge in institutional contexts. In doing so, it sheds light on the feedback loops between the exogenous environment, the community, the rules, the action situation, the actors and their interactions with the exogenous and endogenous variables, and finally the outcomes. The IAD takes into account that the connections between any two or more of these variables are not linear; rather they are complexly nested within each other. This, as many critics argue, adds to the already complex and dynamic picture of institutional analysis. However, if understood properly, the IAD framework puts forward a coherent vocabulary for the study of institutions. Applied correctly, it can help resolve much of the institutional complexity surrounding any given problem without taking away any of the pertinent details.

The IAD framework takes a systems approach to policy processes, whereby inputs, policy-makers, outputs, outcomes, evaluative criteria, and feedback effects are connected to each other in a dynamic manner. Ostrom argues that any complex system can be viewed as being composed of "holons," which constitute the complete sub-systems within an overarching system. These sub-systems, in any complex adaptive system, "can be 'dissected' into its constituent branches on which the holons represent the nodes of the tree, and the lines connecting them the channels

of communication, control or transportation" (Ostrom 2005, 12). It may be argued that in a complex system, it may be a difficult task to comprehensively analyze and understand the overarching system by just analyzing the underlying constituent branches. However, the notion of complex systems, as put forward by Simon (1955), suggests that the sub-system within an overarching complex system is a complete system by itself which can be understood on its own while keeping the dynamics of the overarching system constant. However, if one wants to understand the system from a broader perspective, the level of analysis can always be shifted up through the interlinked channels which bring the underlying sub-systems together.

These intricacies of complex systems are quite comprehensively and conveniently captured by the IAD framework. The framework formalizes the analysis by clearly spelling out the constituent parts and providing a coherent understanding of what these components mean for the entire system. It also highlights the fact that many of the interactions within and across the sub-systems occur simultaneously at multiple levels. The IAD framework therefore provides the institutional analyst with the luxury either to analyze the system as a whole or to focus on a set of sub-systems independently or jointly. It is this very flexibility that is utilized in this paper; instead of focusing on the entire system, this exercise focuses on only the exogenous variables and the action arenas. More specifically, the rules and the participants and the linkages between them are explored in depth. Other parts of the framework, while potentially valuable for such an analysis, will be left for future inquiry.

Another key analytical feature of the IAD is that it allows the analyst to account for possibilities of polycentric governance. Polycentric governance is defined as

> a system of governance in which authorities from overlapping jurisdictions (or centers of authority) interact to determine the conditions under which these authorities, as well as the

> citizens subject to these jurisdictional units, are authorized to act as well as the constraints put upon their activities for public purposes (McGinnis 2011, 171).

Given that most knowledge-based economies rely on polycentric systems of governance, it is imperative for the analyst to be able to dissect the underlying components of a system to be able to point out the governing forces which are exerting an influence on that sub-system and in turn on the overall system. In the context of research partnerships, multi-sectoral and multi-functional polycentric governance becomes the key focus of governing paradigms. These levels of governance can highlight the processes within hybrid organizations arising from interactions of actors and organizations, such as in the case of research partnerships where the public and private sectors interact with academia and with each other in a dynamic manner.

At the simplest analytical level, the IAD framework can be viewed as consisting of exogenous variables, an action arena, and the interaction between these, the outcomes, and the evaluative criteria. All these variables have feedback effects on each other, which keeps transforming the system as a whole as well as the variables themselves. The elements defining the exogenous variables include biophysical or material conditions, attributes of community, and rules. The action arena is composed of the action situations and participants. The interactions between the action arena and the exogenous variables determine the outcomes, which are then evaluated using the criteria appropriate for the given system. The outcomes are fed back onto the action arena and the exogenous variables which results in transformations in one of the holons or in the entire system or in both. While it is important to gain an understanding of all the institutional components of a system, only the exogenous variables, action arenas and the interactions between these holons will be considered in greater depth in the context of technology transfer partnerships. This is not to suggest that outcomes and evaluative criteria are

not important in technology transfer partnerships. However, to delve into outcome and evaluative criteria would require analysis at a much larger level, which is beyond the scope of this exercise. By focusing solely on the exogenous variables and action arenas one can gain significant insights into the dynamics of developing technology transfer partnerships, which can be used to structure the analysis of these partnerships at other levels.

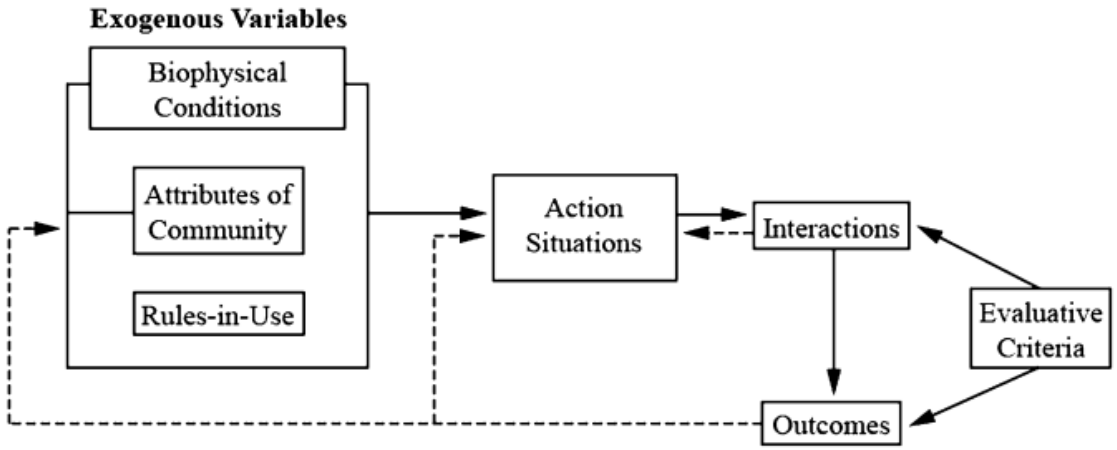

Figure 3.1. Components of the IAD Framework
Source: Ostrom 2005, 15.

3.3. Mapping the Technology Transfer Process onto the IAD Framework

The previous chapter showed some of the key features of research partnerships as well as some of the commonly cited impediments to establishing effective research and technology transfer partnerships. This section maps some of those features onto the institutional framework. Further, it shows how an understanding of institutional characteristics of technology transfer partnerships can help eliminate some of the impediments. Using the defining elements of the IAD, one can analyze each of these elements as they apply to technology transfer partnerships.

3.3.1. Attributes of the Community

As the first step, one has to define the exogenous variables of the IAD related to technology transfer. One of the most fundamental variables in this regard is the attributes of the community. The community of technology transfer partnerships is formed through the coming together of individuals from different organizations whose institutional values differ from each other considerably. This makes it extremely difficult to classify the attributes of the technology transfer partnership community into a common framework. Another problem with technology transfer partnerships and innovation systems in general, is that the community is not static. It is a dynamic entity, where the organizational boundaries of the participants are blurred. As a result of these blurred organizational boundaries, the actors within a technology transfer community can keep changing their identities. Many times, the participants in a technology transfer partnership are holding multiple positions across different organizations. One example of such dynamic character adoption is when the bench scientist or faculty member from the participating university starts taking an active interest in the technology commercialization and therefore has to adopt the qualities and characteristics of an entrepreneur. In such cases, his or her affiliation cannot be bound to the technology transfer community only. The fluidity in individual identities within such partnerships can cause serious problems in defining a boundary around the community.

Despite the lack of common institutional backgrounds, a technology transfer community can be established through iterative interactions. In the case where the attributes of community are not favourable to establishing a collaborative environment, open communications can help build trust, reciprocity, and favourable perceptions. In addition, technology transfer partnerships usually boast valuable social capital, which comes together from different organizational

backgrounds. Presence of such varied social capital can enhance the stability of networks developed within a partnership. Individuals can develop personal ties with other participants and share knowledge with each other. The sharing of knowledge can help develop an organizational code and establish a community which shares common values.

One key to developing a high-functioning technology transfer community in the absence of historical interaction is to provide the community with time to adopt an organizational code. Over time, the partnership community can gain experience through mutual knowledge sharing. The knowledge sharing could be based on technical know-how knowledge, as well as knowledge about organizational practices such as rules, norms, and strategies that should be implemented within the technology transfer community. Organizations such as these partnerships exhibit increasing returns to experience. In this context, the feedback loops from outcomes, evaluative criteria, action arenas, and rules can positively enhance trust, reciprocity, and understanding of common values between the participants. Not only do the individual participants learn from the organizational code by adapting to rules and common values of the partnership, the organizational setup of the partnership can also socialize to their languages, beliefs, and practices (March 1991). In this sense, not only do the individuals evolve, but the organizations also evolve over time. This is a characteristic of any complex system.

3.3.2. Biophysical and Material Conditions

In the technology transfer process, voice content of a good is also deemed important. Phillips (2007) has argued that if production or consumption of an innovative good depends on information provided by others, it is deemed to have high voice content. In knowledge-based economic systems, this is judged to be of critical value as both production and consumption depend on interdependencies of others using and contributing value (Phillips 2007, 238). In the

technology transfer process the three factors (rivalry, excludability, and voice) have a combined effect on the entire system. In innovation systems, as well as technology transfer systems, most of the focus is on goods and services which can exhibit a mixture of these properties. Therefore, while some goods can be classified as purely public, private, or common pool, there is an array of hybrid goods with a mix of these three properties. The exact nature of a product being disseminated through a technology transfer partnership can determine the exact governing mechanism that should be applied.

When one focuses on governing these attributes of a good or service, there is a multitude of possibilities that can arise. Production and dissemination of pure public goods, for example, are thought to be best dealt with by the state. Similarly markets and civil authorities are better suited to oversee the provision of private and common pool goods respectively. The case of hybrid goods is more complicated. With hybrid goods, it is difficult to determine the best institutional setup to govern transactions. Sometimes one of the pure organizational spheres, such as states, markets or civil authorities can accommodate and manage the delivery of the good; at other instances some form of a hybrid organization is required, where the knowledge and expertise from two or more of the domains is needed to effectively and efficiently deliver the good. In addition, there is also a potential for path dependency in the institutional and governance systems for hybrid goods. From this analysis, one can infer that public-private technology transfer partnerships are best suited to deal with hybrid goods. With a mix of public and private organizations as well as organizations that are of a quasi-public nature, partnerships can employ a variety of governing mechanisms. The institutional setup of these partnerships can allow them to develop, adopt and adapt to the changing dynamics of hybrid goods. If the institutional

structure of these partnerships is properly developed, it can greatly facilitate the production and dissemination of innovative technologies with the hybrid characteristics.

3.3.3. Rules

When speaking of research partnerships, specifically technology transfer and commercialization partnerships, rules are the key in defining institutional characteristics. Using the IAD framework, one can apply the concept of rules to the research and technology transfer partnerships in order to gain an in-depth understanding of the governing mechanisms within these partnerships. While all the different generic rules set out in the IAD can be applied to the partnership, these may need to be modified given the context. The following figure presents a generic effect of rules on the system. In the following sections, we develop these rules as they apply to technology transfer and commercialization partnerships.

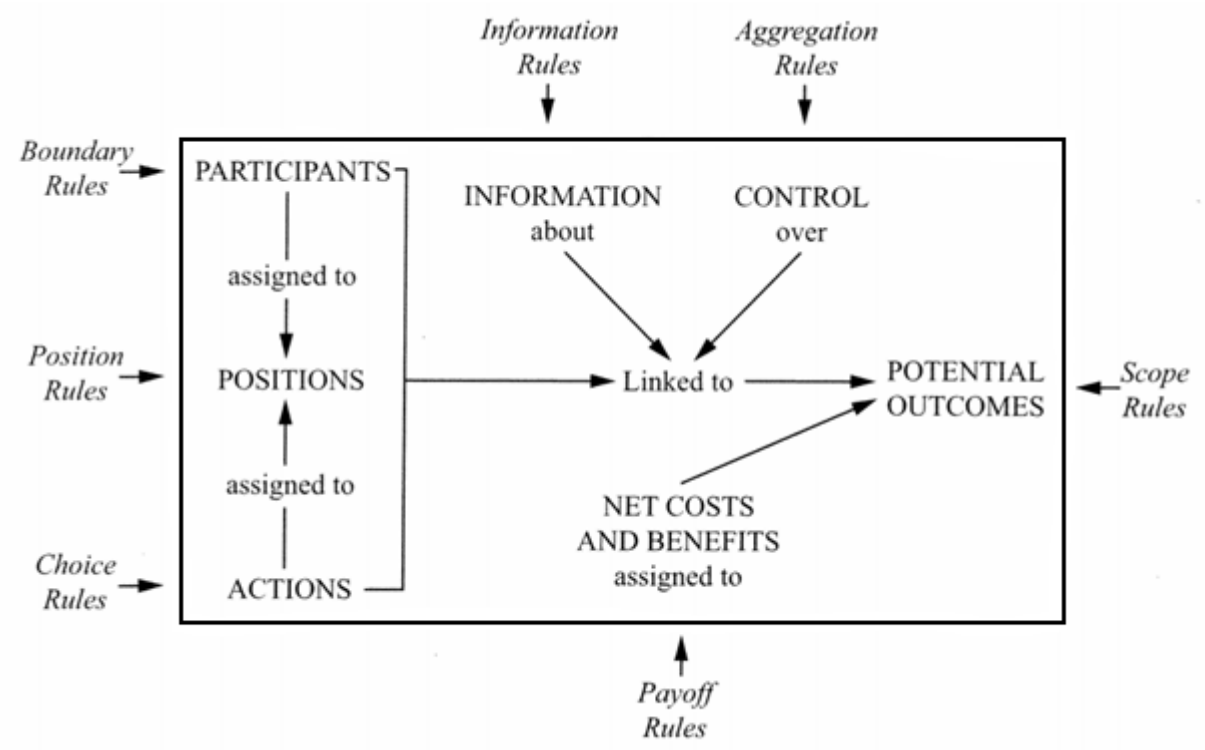

Figure 3.2. Rules and their impact on various components of the system
Source: Ostrom 2005, 189

i. Position Rules

Defining the position rules is the first step in mapping out the entire set of rules for technology transfer partnerships. Position rules, in essence, define the characteristics of stakeholders for the partnership. These can be used to highlight the organizational capacities of all the participating organizations. They also help identify the resources, skills, and knowledge that each of these stakeholders would be able to bring forward (Ostrom 2005, 193-194). As one may imagine, the organizational capacities, resources, and knowledge contained within each sphere can differ substantially. These differences can be both good and bad for the development of a partnership. On the one hand, they introduce diversity into the organizational practices of the partnership; on the other hand, they can cause numerous problems in organizing the stakeholders

in the first place. Position rules can allow sorting out these differences by finding synergies across the participating organizations and only allow those characteristics to define the organizational structure of the partnership which are beneficial for its effective functioning.

Position rules can also help establish the number and variety of participants by defining the number of positions within a partnership. By doing so, these rules can effectively determine the power structure assigned to each position and consequently to each participating organization (Ostrom 2005, 193). Unless there is only one type of position specified, one can assume a hierarchic power structure to be operational within the research partnership. Creating positions within a research partnership can be a complicated task, as each organization has its own set of position rules within the respective organizational setup. By taking into account each organization's resources and knowledge capacities, position rules can help establish a clear set of expectations for each of those involved in a partnership. However, in order to be effective, position rules need to be complemented by authority and boundary rules, which define the responsibilities of the participants holding any given position within the organizational setup of the partnership.

ii. Boundary Rules

Boundary rules, which are also frequently known as entry and exit rules, define the eligibility to enter a position, as well the process through which eligible participants may enter or leave the position (Ostrom 2005, 194). Within technology transfer partnerships, boundary rules determine the conditions by which an organization or an individual may become a partner. The first-order boundary rules define the eligibility of individuals to be members. For example, in technology transfer partnerships, faculties of science, engineering, or medicine and their

respective faculty members would be eligible to be part of the partnership since they contribute towards developing a technology. Similarly, private sector firms and their managers can join a partnership if they are active in the technology sector and have the required set of resources to effectively market a technology. Public sector organizations may find themselves eligible for a partnership through their oversight and regulatory role. The membership of a research partnership is therefore heavily dependent on the eligibility criteria, which in turn depends on the projected outcomes of the partnership. In other words, the proposed objective of a partnership will determine which organizational or individual entity is eligible to participate in the partnership. In addition, eligibility to join a partnership may also depend on an organization's or an individual's experience with such projects. Some faculty members or firms may have a history of successful collaborations with other organizational spheres. Their experiences, therefore, can contribute to establishing an effective partnership between the three organizational spheres.

Boundary rules can also determine whether the participants (organizations or individuals) have control over their decision to be part of the partnership or not. As Ostrom has suggested, open boundary rules allow eligible participants full control over the decision. These rules can be conceived in terms of invitation and compulsion. Boundary rules are considered to be invitations when they authorize holders of a position to select further holders from the set of those who are eligible. Boundary rules are compulsory when eligible participants have no control over whether they fill a position or not (Ostrom 2005, 195). Any combination of these rules can be found in practice; however, given the nature of research partnerships, one can assume that open and invitational rules would dominate. Partnerships are established through voluntary agreement of

different organizations and individuals in order to achieve a common goal. To impose compulsory boundary rules in such circumstances could be detrimental for any partnership.

One of the problems in establishing a technology transfer partnership is the fluidity of the representatives of the participating organizations. Individuals who represent various organizational spheres are extremely mobile. Especially in a dynamic knowledge-based economy, where organizational boundaries are blurred and individuals' characteristics are continuously changing as a result of interactions with other organizational spheres, it is extremely difficult to retain institutional memory. However, once a technology transfer partnership is established, individuals can take up roles within the partnering organizations and institutional memory can be created and preserved. For example, faculty members who are usually responsible for producing innovative technologies can take on the role of entrepreneurs and managers once their technology is introduced in the market. Similarly, technology transfer officers, who act as a liaison between industry and university, frequently switch their positions between industry and university as they follow opportunities.

One of the keys to successful technology transfer and commercialization identified in the literature is that transfer of know-how and tacit knowledge often can and frequently must flow along with a physical technology or product. In the absence of involved individuals, the process could collapse. It can become difficult to establish issue ownership in such partnerships, where individuals cannot be retained for long periods. In such situations, a subset of boundary rules, known as succession rules, can prove key for the effective functioning of a partnership. Succession rules define who is eligible to move from one position to another and what criteria must be met to fill a vacant position. Through the use of boundary rules, procedures can be

established to ensure efficient transition for those who move out of the partnership and for those who move into their positions.

iii. Choice/Authority Rules

The next set of rules that needs to be established for a technology transfer partnership is choice or authority rules. These rules specify what a participant occupying a position must, must not, or may do at a particular point in the light of conditions that have, or have not, been met at that point in the process. The permissibility of actions is dependent on the position of a participant, history of actions taken on that position, and attributes of relevant state variables (Ostrom 2005, 200). These rules effectively define the power structure within a partnership. They highlight the responsibilities assigned to each participating individual or organization. In order to define these authority or choice rules, one can apply the grammar of institutions as developed by Ostrom. Applying the mnemonic ADICO[2] enables the institutional analyst to determine the permissibility of an action under a pre-defined set of conditions. One example of choice rules, commonly used in technology transfer partnerships, is intellectual property rights (IPRs). IPRs determine the licensing terms (conditions) attached to the appropriation (action) by a participant (private firm). One of the critical component of these rules is the OR ELSE statement, which determines the consequences for the decision-making individual in the case where the conditions are not met. Therefore, these rules introduce accountability to the actions of a participant.

[2] ADICO is referred to as the 'syntax of institutional grammar' by Ostrom. **A**TTRIBUTES is a holder for any value of a participant-level variable that distinguishes to who the institutional statement applies (Ostrom 2005, 139). **D**EONTIC component draws on the modal operations used in deontic logic to distinguish prescriptive from non-prescriptive statements. The set of DEONTIC operators comprises of permitted (P), obliged (O), and forbidden (F) (Ostrom 2005, 141-142). The A***I***M is the specific description of a working part in an action situation to which an institutional statement refers (Ostrom 2005, 148). **C**ONDITIONS indicate the set of variables that define when and where an institutional statement applies (Ostrom 2005, 149). **O**R ELSE specifies a range of possible punishments if a rule is not followed (Ibid).

iv. Aggregation Rules

One of the most significant advantages of applying authority rules to a technology transfer partnership is that they help develop a clear set of expectations for participants. By highlighting the expectations from each of the participants in terms of the permissibility of actions, these rules can significantly reduce the conflicts that may arise between actors from different organizational spheres. In addition, these rules are flexible enough that when facing a modification in the range of assigned actions, they can affect the basic rights, duties, liberties, and exposures of members and the relative distribution of power among the participants (Ostrom 2005, 202).

While authority rules define individual responsibilities, individual actions need to be aggregated when there are multiple participants and decision makers. Technology transfer partnerships, which consist of multiple participants from various organizational spheres, require an effective mode of combining the voices of these participants into a combined decision which reflects the partnership as a whole. In cases where each of the organizational participants have their individual concerns and are motivated by different interests, lack of rules to aggregate the individual decisions from different nodes can create significant problems. Therefore, transformation of individual actions into combined decision making requires aggregation rules. These rules determine whether a decision of a single participant takes precedence over decisions by other participants or the decision of a majority applies in a given action situation.

Ostrom has highlighted two subsets of aggregation rules: non-symmetric aggregation rules and symmetric aggregation rules. Non-symmetric rules treat the participants in a situation differently in regard to some decision to be made at some point in a decision process while symmetric rules assign joint control over an action to multiple participants so that all are treated

alike (Ostrom 2005, 202-203). In the case of technology transfer partnerships, one may argue, aggregation rules have to be symmetrically distributed across all the participants in order to develop a sense of equal responsibility across the participating organizations. Unless any single participant or organization is unambiguously better suited to make decisions around a particular action situation, non-symmetrical aggregation rules are bound to create insecurity among the participants. By applying symmetrical decision aggregation rules, technology transfer partnerships can ensure that conflict is minimized and participants do not feel left out.

Another important subset of aggregation rules highlighted by Ostrom is the qualification of "No-Agreement" rules. These rules are to govern those situations where there is a disagreement between participants in an action situation. These rules can be thought of as an aggregative version of OR ELSE as they apply to individual choice rules. These conditions, in a collaborative environment, can specify the consequences of not reaching an agreement. These consequences could be related to the final outcomes or the payoffs to the participants. Some of the consequences that may arise as a result of invoking no-agreement include status-quo, all-or-nothing, random allocation, or external mediation to achieve a certain outcome (Ostrom 2005, 205). Without clearly spelling out no-agreement rules, technology transfer partnerships could run into a deadlock situation, which may effectively end the collaboration.

v. Information Rules

Availability of information is a key determinant in making effective decisions within a partnership. Information is especially important considering that participants in technology transfer partnerships come from different organizational, professional and academic backgrounds and they bring different pieces of information of varying value. In such settings, asymmetries of

information can affect the effective functioning of the partnership. Therefore, it is imperative that the production and dissemination of information within a partnership be governed through some form of information rules, which in turn can inform the participants of the current state of individual state variables, the previous and current moves of other participants in positions, and their own past moves (Ostrom 2005, 206). By having an impact on these variables, information rules basically affect the level of information available to participants.

Information rules can also determine the most effective channel for communicating among the group members by highlighting the required, permitted, or forbidden channels of communication. In technology transfer partnerships, previous literature has highlighted the need for effective communication channels in order to build trust between the partners. In addition, the frequency of exchange of information is also deemed important in determining how well the information is managed within a partnership. Especially in the cases where the partnership is recently developed and there is limited historical information available, frequency of information exchange can enhance organizational learning within the partnership. Therefore, by managing the availability of information, dissemination channels, and frequency of exchange, information rules can effectively govern the information aspect of a partnership, a crucial element in long term development.

vi. Payoff Rules

Payoffs are thought to be the most critical motivating factor for any of the participants in a technology transfer partnership. They are also considered important for aligning the interests of participants with the interests of the organization. Payoff structures can affect the decision making process at the individual level as well as the organizational level. The most contested

arguments surround the payoff structures instituted within a university and their impact on a faculty member's decision to participate in a partnership. It has been suggested that payoff structures within academia have a negative influence on participation in technology transfer partnerships, as more reward is allocated for academic publications but not for technology transfer and commercialization activities (Friedman and Silberman 2003, 17-30). Since these rules directly impact the net costs and benefits of action or outcomes for actors in an action situation, it is imperative that the payoff rules dealing with extrinsic rewards to the participating faculty members be flexible enough to accommodate the realities of a knowledge based economy.

Another aspect of payoff structures that requires formalized rules is profit sharing from the appropriation of a given technology at an aggregate level. One of the biggest impediments in transforming technology into marketable products is disagreement over licensing fees, royalties, and profit sharing from commercialization (Hall, Link, and Scott 2000). These decisions can be effectively governed by a combination of payoff rules and disagreement rules. These rules can account both for the share of costs borne by individual participants and the resource efficiencies of each of the organizations.

vii. Scope Rules

The last rules which need to be implemented at the organizational level are scope rules. Scope rules are required to determine which of the outcomes are affected by a certain action originating from within an action arena. These can be used alternatively to assess the value of an action (Ostrom 2005, 208-210). For example, these can provide an effective alternative to the common evaluative and payoff rules within academic departments of universities where, instead

of judging the quality of research through journal publications, some individuals might be assessed based on efforts to transform technology into commercial products or services. As Ostrom has argued, strong norms and rules governing academic freedom render many university rules governing specific teaching and research activities suspect, while rules that base promotions on outcomes for professors may be seen as much more legitimate (Ostrom 2005, 209). Therefore, instead of aiming for various inputs, these rules can shift the focus onto outcomes.

3.3.4. Action Arena and Action Situations

In a technology transfer partnership, an analysis of action arenas and situations would enable the analyst to gain an understanding of the dynamic interactions between participants, their actions and the linkage between actions and outcomes, as well as the costs and benefits of actions and outcomes (Ostrom 2005, 351). However, much of this analysis depends on the level of analysis--that is whether the analysis is conducted at the operational, collective, constitutional, or meta-constitutional choice level. An analysis at each of these levels requires one to consider the impact of different combinations of exogenous factors on the action arena. It also suggests that the various rules influencing the action arena would have differential propensities for transformation given the level of analysis.

In technology transfer partnerships, the interactions between participants are a critical factor in establishing the efficacy of these partnerships. Once again, these interactions are governed by different rules at different levels. While operational choices may be the easiest to make since they concern day-to-day activities of an organization, choices at the other three levels may prove extremely difficult if not impossible to govern. Problems arise mainly as a result of

different organizational and institutional backgrounds of the participants within a technology transfer partnership. It is therefore essential that one understands the effect of these analytical levels, both from top-down and bottom-up perspectives, and analyze how each affects the next level.

The meta-constitutional level in a technology transfer partnership is comprised of governing institutions of the participating organizations. These institutions exert a significant influence on the functioning of a partnership. For example, the various governing institutions in a university can severely constrain the actions of those who represent the university in a technology transfer partnership. Similar constraints may be in operation over participants from two other spheres. In order for the meta-constitutional level to effectively translate into the constitutional level, the institutional structures of all participating organizations need to be completely synchronized with each other. However, this is effectively impossible to achieve given the time constraints in technology commercialization. Institutional practices are historically embedded in each of the organizations. Institutional evolution at this level may be the most difficult task to achieve in the context of technology transfer partnerships. Even though, some analysts argue that the "culture" of these organizations is catching up with the changing realties, evolutionary movements are often too slow. Consequently, they end up affecting the speed of institutional evolution within the technology transfer partnership.

Situations at the constitutional level are those which need to be resolved at the inception of a partnership. These situations, which are governed by constitutional choice rules, determine the effective rules that govern both collective choice and operational choice situations. In technology transfer partnerships these may involve establishing the proposed objective of the partnership, the number of participants, their effective role within the partnership and modes of interactions.

These choices are usually highlighted in a proposal for establishing a partnership and are effectively developed before a partnership is functional.

Choices at the collective level of decision-making affect various organizational processes including cost-benefit decisions to commercialize a specific technology, the marketing structure, and the payoffs. These decisions are in turn affected by choice rules operating at the individual and collective levels. Collective choice problems involve participation of various actors simultaneously and combining their individual actions into a collective outcome. They are also affected by the information available to the group regarding past actions and outcomes from similar situations, as well as by the social capital available within the organization. Collective choice situations highlight the opportunities available regarding a particular situation that is being dealt with at any given point in time. Consequently, they establish the link between actions and outcomes within that particular action situation. It must be noted here that in technology transfer partnerships, collective choice situations are affected by multiple control variables functioning within the organization. In essence, individual actions may be necessary conditions for an outcome, but they are not sufficient to guarantee that outcome. Technology transfer partnerships are riddled with stochastic disturbances, represented in the transformation function, which may be aggravated at the collective choice level. Therefore, it is necessary to account for the probabilistic nature of collective choice decisions within a partnership in order to gain comprehensive understanding of the action-outcome linkages in the technology transfer partnership.

Operational choice decisions, as mentioned earlier, are the most flexible and easiest to understand in the context of technology transfer partnerships. These decisions are governed by operational choice rules which affect individual decision making. One of the key factors

influencing the actions and decisions of individuals at this level is the availability of information to each individual about the actions and decisions of others. Especially in the case of technology transfer partnerships, where participating organizations may have different underlying motives, availability of information may critically affect the actions and decisions at the individual level. With asymmetric and incomplete information, participants may behave opportunistically when outcomes are jointly determined at the collective choice level. Consequently, behaviours can prove to be detrimental to the efficiency of the partnership and, therefore, may need to be governed through rules to alter these behaviours.

Going from the meta-constitutional level to the operational level is only one way of analyzing the different scales of the picture. If one is more interested in the working dynamics of a partnership once it has been developed, then the analysis of action situations and action arenas can be reversed. Conducting an analysis in that fashion allows the analyst to understand the dynamics of institutional change within the organization and at the broader societal level. However, to conduct such an analysis one has to ensure that there is a defining set of rules already in place and the analysis can only apply to the rate of transformation in those rules from the individual to organizational to societal level.

i. Uncertainty

One of the key impediments, as highlighted in chapter one, is the uncertain outcomes of technology commercialization—the embryonic state of technology, market application potential, and statutes of effective legal protection are key sources of uncertainty in technology transfer partnerships. However, this is not the full story. While these factors do add to the risk of unsuccessful outcomes from technology commercialization, uncertainty in the context of

technology transfer partnerships usually arises from social interactions between participants, as well as conflicts between organizational practices of the participant organizations. Many social interactions in the world are characterized by certain indeterminacy. It is complicated even further where action arenas are composed of multiple participants from different institutional backgrounds, as is the case in technology transfer partnerships. In such cases, the probabilities of specific actions leading to outcomes are unknowable (Ostrom 2005, 49).

The uncertainty in these situations can be reduced by undertaking a repeated game theoretic approach within the institutional framework. The literature on game theory suggests that in these situations, participants can still achieve optimal outcomes, provided the situation is repeated over time and the actions of other participants are observable through codified rules. Such repeated observations in the case of technology transfer partnerships can be best captured through the institutional analysis framework. The framework has the unique capacity to allow for feedback loops to operate on not just the action situation but other exogenous variables as well. These feedbacks ensure that over time uncertainty is reduced, if not completely eliminated. Through feedbacks participants in an action situation have the opportunity to observe the actions of themselves and their peers within the partnership. These feedbacks reduce uncertainty by giving the participants an opportunity to make decisions informed through historical projections.

ii. Nested Holons

Another characteristic of action arenas, action situations and rules within the institutional analysis framework is their nesting with other action arenas, situations and rules. While holons are used to govern one specific problem within a system, they are also linked to other arenas within the broader system (Ostrom 2005, 351). In the case of a technology transfer partnership,

the action situation is deeply entrenched in other action situations within the broader innovation system, which is comprised of organizational actors drawn from the university, private and public sectors. The actions and decisions taken within the technology transfer sub-system affect the dynamics of innovation in these organizations. In turn, the institutional practices and their transformations at the individual organizational level affect the functioning of the technology transfer partnership. In these partnerships, the actions of participating organizations can therefore be thought of as a tree or a lattice with action situations at each node. A particular rule set structures the situation at each node. A general set of rules partially structures all internal situations and specifies the paths that may be chosen to move from one situation to the next.

The action arena in technology transfer partnerships can be thought of as composed of a series of linked action situations, which can be analyzed simultaneously or under the assumptions of *ceteris paribus*. While in most social interaction situations it is feasible to adopt the latter assumption, in knowledge-based innovation systems most action situations undergo simultaneous transformations. The IAD framework provides an ideal platform to capture both static and dynamic transformations through feedback effects, which in effect have the capacity to act as transforming catalysts. In other words, the feedbacks from various nodes in a system have the capacity to alter the underlying institutional dynamics of not only a given action arena, for example the technology transfer partnership, but the related action arenas in participating organizations, such as academia.

3.4. Conclusion

This chapter has presented an institutional framework for the analysis of technology transfer partnerships. Applying components of the IAD framework can extend an understanding

of the underpinnings of the technology transfer process. Even though the framework has not been utilized in its entirety, the dynamics of technology transfer partnerships have been laid out in a more comprehensive manner than in other studies. The IAD framework enables decomposing the innovation system into its constituent sub-systemic parts and analyzes the effect of various institutional forces acting on specific sub-systems. One of the key contributions of this framework is that it captures not only the superficial interactions between participants and their links to the outcomes but it also allows the analyst to delve into the cognitive underpinnings of these interactions at the individual level. The cognitive underpinnings are an extremely important link to understanding the dynamics of a complex system which are shaped by interactions of multiple actors. The next chapter examines various behavioural theories and their application in the context of technology transfer partnerships and how they affect the institutional structures of these partnerships.

Four

Participants in Technology Transfer Partnerships: A Behavioural Analysis

Individual participants have a key role to play within any institutional structure. Participants within a system act as links between rules, actions, and outcomes. They influence the interactions and transformations of various institutional blocks. In the process, individuals are also affected by these institutional blocks. In other words, the interactions between institutional structures and participants are endogenous. Understanding the behavioural motivations of participants becomes even more crucial within technology transfer partnerships, an important sub-system of the broader innovation system. Participants in these partnerships come from different institutional backgrounds and therefore do not share a common set of mental processes with each other. As shown previously, technology transfer partnerships belong to a complex innovation system and therefore understanding the mental modes of decision making within such systems is even more complicated than in simple social interactions.

Individual participants act as decision makers under the influence of exogenous variables in a system. They animate a system, by linking rules, actions, and outcomes. It is therefore imperative to carefully analyze the various cognitive processes that drive participants in a system to take certain actions. Such an analysis ought to consider the kind of information participants

possess, the relevant preference structure of participants, and the process they use for choosing among actions. Key assumptions about information, preferences, and choice mechanisms need to be drawn out in order to gain an understanding of the dynamics of an action situation, the outcomes, and the interaction between participants, actions, rules, and outcomes.

This chapter examines the different behavioural forces that affect individual decision making processes within a technology transfer partnership. It makes use of some of the core literature on behavioural underpinnings of decision making in organizational settings. The literature helps identify the impact of behavioural and cognitive capacities on decision making in complex systems. The findings from literature are linked to participants in technology transfer partnerships, which allow the reader to gain an understanding of cognitive forces at play in these partnerships and how they affect the interactions between other components of institutional structure.

In the first part of this chapter, a brief comparative overview of various cognitive theories of decision making is presented. The discussion revolves around various assumptions of the classical rational choice theory and some of the counter arguments presented in other behavioural theories, such as bounded rationality and cognitive framing. Sketching out the postulates of these theories helps the reader to view the evolution of behavioural decision making theories over time. Then key assumptions regarding participant behaviour from the IAD framework are presented in the second section. Finally, these assumptions along with other theoretical observations from the literature on decision making are mapped onto technology transfer partnerships. The objective of this chapter is to extend an understanding of the impact of cognitive capacities of individual participants on technology transfer partnerships.

4.1. Theories of Decision Making

4.1.1. Rational Choice Theory

Traditionally, the analysis of individual behaviours in social settings has assumed a rational choice approach. This approach suggests that individuals act rationally in social interactions given certain assumptions about information, valuation, and maximization. Such an approach is deeply embedded in classical economic and political thought. The literature in these fields has long assumed that individuals act rationally to make transactions in markets, within political institutions, and in other fields of life. The assumption is that individuals will maximize their utility from any given decision as long as they have access to complete information and they can fully evaluate the payoffs of their actions.

The rational choice theory works well in relatively stable environments where uncertainty is low due to historical experiences. In static environments, where the analyst can focus on one variable and observe its effects as other variables are held constant, the predictions from rational choice are generally reliable. However, in complex and dynamic interactive situations, as is the case in knowledge-based economies, the predictive accuracy of the theory falls considerably. In complex situations, there is a lot of uncertainty around the nature of interactions and their impact on outcomes. In addition, participants have a less than complete grasp on all the pertinent information. Furthermore, participants are challenged by inconsistent extrinsic and intrinsic evaluations being placed on the payoffs from a given situation. Over the years, experimental researchers have shown these inconsistencies undermine the reliability of predictions under rational choice. These inconsistencies have led researchers to start considering other behavioural models in complex decision making environments.

4.1.2. Behavioural Theories of Decision Making—Bounded Rationality

To account for the inconsistencies of the rational choice theory, scientists have developed models which factor in behavioural inconsistencies of individual decision makers. One such attempt, formalized by Simon (1955), posits that individuals exhibit "bounded" rationality instead of comprehensive rationality. He argues that individuals in complex situations do not have the necessary computational skills to be able to fully analyze the information and alternatives available to them. Therefore, the main problem is not lack of perfect information or alternatives; rather it is a matter of how much cognitive control individuals have over rational adaptation.

It has been argued that individuals usually make certain cognitive calculations about the amount of information and the relationship between alternatives and pay-offs. Using these calculations, the optimal outcome may involve selection of a certain maximum of an expected utility (Simon 1955, 101). In essence, the theory suggests that some of the constraints that traditional Rational Choice theory assumes to be environmental may instead be psychological or physiological. As Simon has argued, "what we call 'the environment' may lie, in part, within the skin of the biological organism" (Ibid). These constraints place a boundary on the computational capacity which can alter the way rationality is perceived under particular circumstances.

Bounded rationality also suggests that given psychological constraints, individuals are not able to conduct a simultaneous search for information and alternatives; rather alternatives are often examined sequentially. In instances where alternatives are examined sequentially, individuals may pick the first alternative which satisfies their aspiration level for that problem. Aspiration levels in turn are linked with the level of difficulty of finding alternatives. Simon has

argued that “as the individual, in his exploration of alternatives, finds it easy to discover satisfactory alternatives, his aspiration level rises; as he finds it difficult to discover satisfactory alternatives, his aspiration level falls” (Simon 1955, 111). The setting of aspiration targets at a cognitive level, therefore, tends to bring about a “near-uniqueness” of the satisfactory solutions. The satisfactory solutions, however, may not be located at global optima; rather, they represent local maxima, which serve to satisfy the individual.

Bounded rationality has transformed the mindset of social scientists studying individual decisions under complex situations. The concept of bounded rationality has found its way into the fields of economics and political science, so much so that many theorists are now reluctant to assume comprehensive rationality. Later studies, building on bounded rationality theory, have expanded the horizon for understanding cognitive underpinnings of individual behaviour in complex situations. Jones (1999) has outlined a number of political and organizational situations where decisions are characterized by bounded rationality. It has been argued that the behaviour of organizations mimics the bounded rationality of the actors that inhabit them (Jones 1999, 302). This argument has been extended to studies of various political organizational variables such as limited attention spans, habituation and routine, and organizational identification.

Further applications of bounded rationality can be found in areas including incremental budgeting, electoral behaviour, and organizational habits and routines. In the case of organizational learning, the theory suggests that cognitive limits of human decision makers constrain the ability of an organization to adjust to its environment. Consequently, learning in organizations ends up being a slow, evolutionary, conflictual process, rather than the instantaneous process that rational organization theory would imply (Jones 1999, 304). These observations from the behavioural theories of decision making provide a great bridging

mechanism within the institutional analysis of technology transfer partnerships, as will be demonstrated in later sections.

4.1.3. Behaviour Theories of Decision Making—Prospect Theory

Beyond bounded rationality theory, one great stride in extending the understanding of underlying cognitive processes which govern the participant behaviour in complex systems has come from Daniel Kahneman and Amos Tversky. Their collaboration in studying the cognitive limitations of human mind and their impact on decision making culminated in what is now famously known as Prospect Theory. The theory, which was first formally presented in 1979, sketches an alternative conception of Expected-Utility theory. The theory posits that individuals tend to be relatively risk averse in a domain of gains and relatively risk seeking in a domain of losses. This argument basically refutes the historically established conception of probability and cognitive consistency of preferences. In the process, the theory also challenges the long standing axioms of rational modelling of expected utility theory, which include assumptions on transitivity, dominance, and invariance of preferences. However, these are only the basic propositions of this theory. In order to trace the cognitive roots of bounded rationality, one has to dig deeper into the constituent components of the theory.

In essence, Prospect Theory follows a two-step procedure: the first phase of this procedure is known as the editing or framing phase while the second is termed as the evaluation phase. The editing phase encompasses what are widely known as framing effects, while the evaluation phase involves the decision process of choosing among options. The decision process in this phase is further influenced by two processes: perceptual likelihood of the outcomes and assessment of

subjective value by using heuristics of judgement. These three processes encapsulate the major topics of the work conducted by Kahneman and Tversky.

In their work, Kahneman and Tversky distinguish between two governing systems which operate at the cognitive level—System 1 and System 2. It is believed that System 1 controls the decision making process at an intuitive level. The operations of this system are fast, automatic, effortless, associative and difficult to control or modify. In contrast, System 2 operations are slower, serial, effortful, and deliberately controlled; they are also relatively flexible and potentially rule-governed (Kahneman 2002, 450). System 1 is therefore responsible for governing intuitive judgements, which deal with concepts as well as with perceptions. System 2 on the other hand is involved in all judgements, whether they originate in impressions or in deliberate reasoning. The main task of System 2 is to monitor the quality of both mental operations and overt behaviour. Studies have shown that the monitoring activity of System 2 is quite lax and allows many intuitive judgments to be expressed, including some that are erroneous. These erroneous intuitive judgements are more likely to be expressed under complex situations, where individuals are faced with dynamic interactions under time constraints.

One factor that determines which system governs the decision process in any given situation is accessibility. Accessibility has been defined as the ease with which particular mental contents come to mind. If a concept is highly accessible, System 1 processes would overrule System 2 processes, and the judgment would be made at the intuitive level. For example, relational properties are thought to be accessible. It has been suggested that the acquisition of skill selectively increases the accessibility of useful responses and of productive ways to organize information. Other factors which can affect accessibility include stimulus salience, selective attention, and response activation (Kahneman 2002, 453). Kahneman has argued that

accessibility reflects "temporary states of priming and associative activation, as well as enduring operating characteristics of the perceptual and cognitive systems" (Kahneman 2002, 454). Many familiar social categories temporarily increase the accessibility characteristics linked with the specific stereotypes within that category, which lowers the threshold for recognizing manifestations of these characteristics (Ibid). This suggests that in the absence of a system that reliably generates appropriate canonical representations, as when individuals are faced with cognitive limitations or bounded rationality, intuitive decisions will be shaped by the factors that determine the accessibility of different features of the situation. Features that are highly accessible will influence decisions, while features of low accessibility will be largely ignored.

The core component of Prospect Theory deals with the framing effects, which define the editing phase of cognitive processing of a given situation. In their argument on framing effects, Kahneman and Tversky have challenged the assumption of rational choice theory which posits that preferences are not affected by variations of irrelevant features of options or outcomes. This assumption, commonly referred to as extensionality and invariance, is an essential aspect of the rational-choice model. However, based on theoretical and experimental evidence, Kahneman and Tversky have shown this assumption to be violated due to the framing effects. In essence, framing effects evoke different responses when a situation is framed differently. One frequently cited example to illuminate this observation is that of the "Asian Disease"[3] (Kahneman 2002, 457). The example highlights the reality that outcomes that are certain are over-weighted relative to outcomes of high or intermediate probability (Kahneman and Tversky 1979, 280-284). Such

[3] Asian Disease refers to an experiment conducted by Kahneman and Tversky during their study of framing effects. The study highlights how individuals react to two different programs when the perception of both programs differs in terms of their capacity to prevent losses or to allow gains.

assignment of differential weighting to the same events challenges the notion of invariance, which in turn puts into question the soundness of rational choice models.

The second process which defines Prospect Theory constitutes perceptual likelihood of the outcomes. It has been argued that perception is reference-dependent. A contrast between the focal stimulus and a context of prior and concurrent stimuli determines the perceived attributes of the focal stimulus. Kahneman and Tversky have argued that dependence on reference frames to perceive a specific focal stimulus also shows through decision making. In other words, the evaluation of decision outcomes is thought to be reference dependent. Such a notion of reference dependence counters the postulates of Expected Utility Theory, which is in essence reference independent. Expected Utility Theory assumes that the value that is assigned to a given state of wealth does not vary with the decision maker's initial state of wealth. Khanmean and Tversky have challenged this assumption by suggesting that the effective stimulus is not the new level of stimulation; rather it is the difference between the stimulus itself and the existing adaptation level (Kahneman 2002, 261).

The notion of reference dependence in perceiving outcomes has also been proven experimentally. The experimental evidence has shown that in cases involving gambles with options to win and lose with different outcome values, most people will reject a gamble with even chances to win and lose, unless the possible win is at least twice the size of the possible loss (Tversky and Kahneman (1992) quoted in Kahneman 2002, 452). Such abrupt transition from risk aversion to risk seeking and vice versa, the authors of this theory argue, could not plausibly be explained by a utility function for wealth. Preferences appear to be determined by attitudes to gains and losses, which are defined relative to a reference point. Prospect Theory therefore

presents an alternative to the rational choice model of risk perception by embracing the idea that preferences are reference-dependent.

To capture the reference dependence of preferences, Kahneman and Tversky have proposed a value function, which is defined in the domains of gains and losses. The function is thought to be concave in the domain of gains, favouring risk aversion and convex in the domain of loses, favouring risk seeking. The most important feature of this value function is that it is sharply kinked at the reference point and assumes loss-aversion. In other words, the function is steeper for losses than for gains by a factor of 2-2.5 (Kahneman, Knetsch & Thaler (1991) Tversky and Kahneman (1992), quoted in Kahneman 2002, 462). Several studies since the presentation of this representation of risk framing have confirmed that the functions in the two domains are fairly well-approximated by power functions with similar exponents, both less than unity (Swalm (1966) & Tversky & Kahneman (1992), quoted in Kahneman 2002, 462). These findings therefore provide an important step in the understanding of utility maximization and risk perception in that the value function reflects an anticipation of the valence and intensity of the emotions that are experienced at moments of transition from one state to another. It suggests that utility cannot be separately assessed from emotional charges.

The third process which Kahneman and Tversky, as well as other behavioural scientists, consider to affect the decision making process is assessment of subjective value by using heuristics of judgement. Heuristics are described at various times as principles, as processes, or as sources of cues for judgement (Kahneman 2002, 466). Kahneman and Frederick (2002) have extended the definition of a generic heuristic process which is termed as attribute substitution. In such a process, "a judgement is said to be mediated by a heuristic when the individual assesses a specified target attribute of a judgment object by substituting a related heuristic attribute that

comes more readily to mind" (Kahneman and Frederick (2002), quoted in Kahneman 2002, 466). It has been shown through experimental evidence "that people rely on a limited number of heuristic principles which reduce complex tasks of assessing probabilities and predicting values to simpler judgmental operations" (Tversky and Kahneman 1982, 3-20). The use of heuristics, it has been argued, can significantly bias the judgement process and result in erroneous predictions about outcomes.

Since the inception of research in the area of heuristics, scientists have developed an extensive list of heuristics which affect the judgemental process. Prospect Theory, however, relies on three major heuristics thought to affect the judgment process--representativeness, availability and anchoring. These heuristics are believed to induce various systematic biases in the decision-making process, including non-regressive prediction, neglect of base-rate information, overconfidence, and overestimates of the frequency of events that are easy to recall. The theory also extends the concept of heuristics beyond the domain of judgement about uncertain events and proposes an explicit treatment of the conditions under which intuitive judgements can be modified or overridden by the monitoring operations associated with System 2 (Kahneman 2002, 465-466). Therefore, an analysis of the function of heuristics in the decision making process ties the entire cognitive process underlying decision making to the outcomes.

It has been argued that use of heuristics is not the main problem when it comes to analyzing erroneous decisions; rather it is the fact that individuals relying on these heuristics are unaware of the substitutions they make at the cognitive level. Since the cognitive illusions that are produced by attribute substitutions have the same character, the individual mapping the attribute onto the scale of another is unaware of this substitution. Kahneman has hypothesized that this could be related to the functioning of System 1 and System 2 which control the intuitive

and controlled cognitive processes. The implication of this assumption is that errors of intuitive judgement could involve both systems: System 1, which generated the error, and System 2 which failed to correct it. Since System 2 is involved in monitoring all decisions, voluntary or intuitive, there could be two possible outcomes of the intervention of System 2. The intuitive judgement, which may be based on a heuristic, may be adjusted or rejected and replaced by another conclusion. However, the intuitive impression is still likely to be prevalent as it precedes the statistical calculation and therefore, more likely to serve as an anchor for subsequent adjustment. This implies that even adjustments will prove insufficient in correcting the erroneous mapping of attribute mapping onto the original stimulus.

The conclusions derived from Prospect Theory have proven to be ground breaking in understanding the cognitive processes underlying individual decision making. They have challenged the long standing assumptions of rational choice, expected utility and many more theories which had long informed the analysis of decision making in social interaction settings. The findings of this theory regarding framing effects, perceptual valuation of outcomes, and use of heuristics in producing erroneous judgements can greatly inform this particular analysis, which involves individuals responsible for decision making under complex, dynamic and uncertain conditions.

4.2. Behavioural assumptions of the IAD framework

The IAD framework assigns a critical weighting to the behavioural assumption of participants within an action situation. The framework establishes key assumptions about cognitive underpinnings of participant behaviour that are used to “animate” the institutional setup. The variables which are considered important in informing participant behaviour include

information processing, preferences, and choice mechanisms. One key characteristic of the framework is that instead of using the comprehensive rationality model for predicting participant behaviour, it makes use of the more sophisticated theories such as bounded rationality and prospect theory. It also relies on more advanced explanations of individual learning processes, which can prove challenging under complex and uncertain decision making environments. Let us now focus our attention on those cognitive assumptions which hold the key to explaining individual participant behaviour in an action situation.

4.2.1. Information

Assumptions about information gathering and processing are deemed critically important within the IAD framework. The framework recognizes that most complex social interaction situations face the challenge of imperfect and/or incomplete information. In such situations, a participant may be faced with the prospect of asymmetric information. The framework posits that "when other-regarding preferences and/or intrinsic values are assigned to outcomes and actions, the situation is one of incomplete, rather than complete, information because other players cannot know exactly how an individual is valuing these actions and outcomes" (Ostrom 2005, 102). Incomplete and imperfect information can bias the analysis in systems comprising dynamic interactions between the participants.

One characteristic of the IAD framework which makes it distinctive from other institutional frameworks is that it allows the analyst to choose the focal level and consequently the appropriate behavioural assumptions within a particular action situation. For example, if the focus of analysis is on stable and repetitive situations where intrinsic values are important, then one can retain the assumption of full information about the structure of the situation. In most

complex and uncertain situations, however, participants are faced with cognitive limitations which can hamper their capability to search for information and analyze it in a comprehensively rational manner. In most complex situations, as Simon (1955) and other behavioural theorists have posited, the available information may greatly exceed the competence of an individual to compute a solution based on fuller analysis (Heiner 1983 quoted in Ostrom 2005, 102).

To capture the process through which participants gather and process information, the IAD framework sketches out a comprehensive map of mental models through which information search and processing is related to actions and outcomes. It has been argued that individuals attempt to create a mental model or a representation of diverse situations so as to be able to make reasonable decisions in these multiple settings. The argument also suggests that mental models are affected by feedbacks from the world and the shared culture or belief system in which individuals are operating (Ostrom 2005, 105).

The process of information search suggests that within an action situation, participants receive information about the structure of the situations. Participants then design an appropriate model of the situation through repeated interactions in it or similar structures, or they can rely on earlier mental models formed of that particular situation if they have dealt with the situation previously. The information search process is thus affected by the historical outcomes that have been previously experienced within an action situation. In addition to historical experiences, the mental models are also affected by cultural belief systems. Cultural belief systems are in turn affected by exogenous variables acting upon the action situation. In the presence of rules and shared cultural beliefs, the diversity of mental models that individuals hold within an action situation is said to be reduced to a smaller set. Therefore, the shared experiences and belief systems can reinforce the mental models used by the participants in a given action situation.

An extension of this argument suggests that in relatively stable and repetitive situations, individual participants will converge to a common mental model of information search, processing, and decision making. This assumption, however, emerges from the rational choice school and may not hold in complex dynamic situations with a large number of participants. In these situations, participants may or may not be able to interact with each other at frequent intervals. Challenged with cognitive limitations and faced with incomplete information, individual participants may make errors in perception, in their comprehension of how a complex structure works, or simply in computations (Vincent Ostrom 1986 and 1997 quoted in Ostrom 2005, 106).

Various behavioural theories have suggested that situations experienced by individual participants are interpreted differently by these individuals. In addition, the response time to an information signal also varies across individuals. Disproportionate information processing implies that a direct link between inputs and outputs cannot be established. The gap between inputs and outputs gives rise to an imperfect match between the adaptive strategies participants may devise and the information they receive. In this case, understanding the common behavioural patterns of decision making in an action situation could prove extremely challenging. To counter these challenges, Ostrom has highlighted Frohlich and Oppenheimer's findings related to environmental factors which affect the perception of participants about a particular action situation. These properties are referred to as salience and vividness of the action situation. Salience is defined as "the degree to which an element is linked to possible changes in the welfare of the decision maker," while vividness refers to the "amount and quality of the sensory details of the objects encountered" (Frohlich and Oppenheimer 2001, quoted in Ostrom 2005, 107). Ostrom argues that these variables are important in gaining attention given the

variety of signals an individual receives. As a result, these variables can inform the analysis as to which information will be received and retained as well as how that information will be processed by the participant.

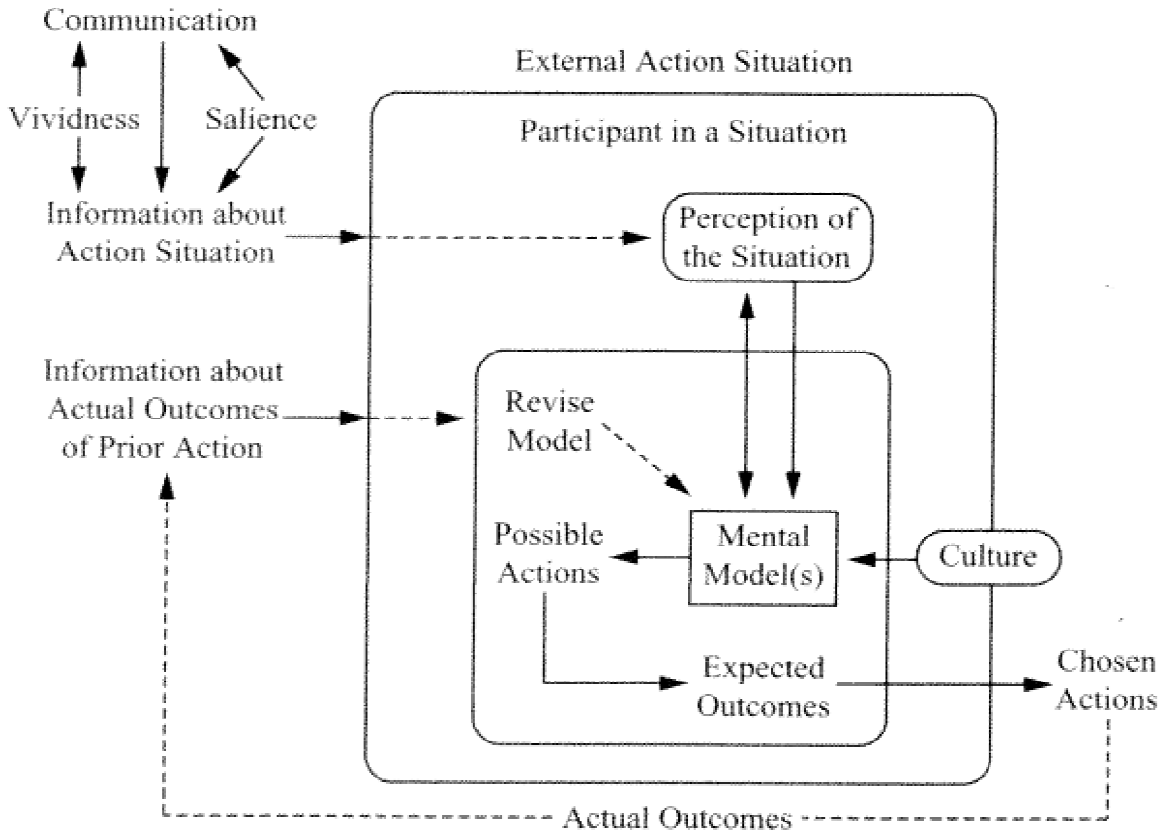

Fig. 4.1: Impact of communication, vividness, and salience on the relationship between information, action-outcome linkages, and internal mental models.

Source: Ostrom 2005, 108.

4.2.2. Valuation

Much of traditional thought on individual behaviours in social interaction settings has assumed that individuals in a situation assign consistent external valuations to payoffs. Another assumption usually made in the classical rational choice framework is that individuals are only

concerned about maximizing their own utility. These assumptions, yet again, are shown to be deficient in complex dynamic situations with multiple participants. It has been shown that the preferences of individuals in such situations are not only concerned about the extrinsic valuation–intrinsic valuation also plays a critical role in determining the overall valuation of an outcome or a payoff.

It has been argued that intrinsic valuation of preferences can partially dictate the preferred behaviour of participants in regards to themselves and others in an action situation. The intrinsic valuation is in turn affected by the sense of self-determination and self-esteem. Ostrom argues that positive intrinsic motivation is increased when individuals feel that their own self-determination or self-esteem is enhanced. This implies that intrinsic motivation can be "crowded out" in situations where individuals do not perceive they have sufficient self-control over their actions (Ostrom 2005, 112).

There are two possible avenues through which the level of intrinsic motivation can be affected. First, external interventions can crowd out intrinsic motivation if the individuals affected perceive them to be controlling. In that case, both self-determination and self-esteem suffer, and individuals react by reducing their intrinsic motivation in the activity controlled. Second, external interventions can crowd-in intrinsic motivation if the individuals concerned perceive it as supportive. In that case, self-esteem is fostered, and the individuals feel that they are given more freedom to act, which enlarges self-determination. Based on these observations, one can conclude that individuals not only differ in their mental models but they may also differ in regard to their internal valuation patterns. These internal valuations may inform the extent they take others into account in the decisions they make and the intrinsic valuation they may

place on taking particular types of actions or reaching particular types of outcomes (Ostrom 2005, 113).

4.3. Technology Transfer Partnerships: Behavioural Analysis of Participants

The theories of cognitive underpinnings of individual behaviour can be used to predict the behaviour of participants within technology transfer partnerships. In addition to bounded rationality and prospect theory, further insights can be gained through other areas where cognitive and behavioural theories of decision making have been previously applied. One such area is entrepreneurship. Studies on entrepreneurship can prove instructive as technology transfer partnerships encapsulate structures which closely resemble action situations in these areas.

Technology partnerships are developed to promote technology transfer and commercialization through collaboration between the university, public sector, and private firms. These partnerships are comprised of individuals who come together from different organizational backgrounds. Therefore, it is an interesting proposition to analyze how these individuals manage complex interactions, search for information, process the information at the cognitive level, and make decisions in these complex situations. The literature suggests that each individual has a different set of cognitive processes to reach a decision. Moreover, membership of different organizational backgrounds and a variety of institutional rules diversifies the cognitive models employed by individuals participating in a partnership. Examining how individuals deal with this cognitive diversity in a complex situation makes for an interesting inquiry, and an understanding of the cognitive phenomena at work within these partnerships highlights the complexity within such partnerships, at both organizational and individual levels.

The first step in technology transfer partnerships consists of information search, which is comprised of multiple layers. This information search process first involves searching for appropriate partners who have the necessary capabilities to promote technology transfer and commercialization. To make an account of the varied organizational and institutional capital that these individuals would contribute to commercialization requires an extensive search process. Often the primary proponent of a partnership is required to conduct this search and get all the organizations and their representatives at the table. The proponent, therefore, is responsible for liaising among these organizational spheres in order to gather all the pertinent information. Gathering information regarding each partner's institutional and individual capacities is a daunting task. The person in charge of gathering this information may be faced with the prospect of incomplete and asymmetric information. Assuming that those involved with this aspect of information search would utilize comprehensive rationality could lead to faulty assumptions. There is always uncertainty about the exact capacities of potential partners, especially private sector firms where secrecy abounds. In addition, proponents usually face a serious time constraint which can hamper the cognitive calculations that need to be conducted at the individual level. In such complex situations, it is impossible for the individual to comprehensively analyze all the information available and make accurate and infallible judgements.

One key impediment to developing a technology transfer partnership is the unfavourable perception that participants may hold towards each other. Due to lack of common cultural values, as well as divergent cognitive models, participants often hold differing opinions about each other and expectations of each motive in pursuing a partnership. It can be argued that there is a win-loss mindset among the participants towards each other. The ultimate goal of commercializing

technology and its payoffs could be viewed as losses at the individual level. An individual participant may feel that other participants may stand to gain more through the commercialization and transfer activity. Such feelings of potential loss may trigger a participant to employ cognitive heuristics, which would eventually lead the participant to undertake riskier actions. Consequently, such decisions under the cloud of uncertainty can lead to unanticipated outcomes, which in turn could dent the efficiency and credibility of the entire collaborative technology transfer organization.

Individuals who belong to different organizational spheres also need to decide whether or not they want to join a partnership. These decisions could be informed by multiple cognitive processes. Individuals could be influenced by the extrinsic and intrinsic valuations they place on the outcomes that may be achieved through the technology transfer partnership and commercialization activities. Researchers who are responsible for developing an innovation may be influenced by the extrinsic valuation of payoffs associated with commercializing that technology. If, for example, the payoffs are large enough and visible through processes such as promotion and higher salaries, an individual might be extrinsically motivated to engage in these activities. If the intrinsic valuation of factors such as reputation, credibility, and informal recognition are also favourable, that may reinforce the extrinsic motivation. Individuals may also place contradicting valuations on these accounts, which in turn might determine the overall motivation to participate in the partnership.

Once the dimensions of various partners have been established, the next most important step in a partnership is to establish the scope of the effort (e.g. the technologies to be transferred or commercialized). This is probably the most cognitively complex process that participants in a technology transfer process undertake. Once a technology is developed in a university or public

lab, technology transfer personnel are usually responsible for establishing a list of potentially viable uses. In consultation with private sector partners and the faculty involved in the development of a particular technology, the technology transfer officers are responsible for determining whether or not the technology has commercial value. The choices of technology and the avenue chosen to commercialize the technology trigger the cognitive processes outlined in previous sections.

The viability of a technology in commercial markets is at best uncertain at the time when key decisions regarding its commercialization are made. It could prove a risky venture if it fails to take off in the market. Prospect Theory informs us that when faced with a probabilistic choice, the ultimate decision is dependent on the reference frame as well as on the perceptual outcomes involved. If the individuals are in the domain of gains, they would be risk averse and choose the more certain outcome. On the other hand, if they are in the domain of loss, they would choose the riskier option. What this means for the technology transfer activity is that, given the risky nature of commercialization, if the participants in a technology transfer partnership are in the domain of gains, they will opt for a commercialization pathway that has at least twice the chances of success in the markets as compared to failure. The domain in this case could be determined through historical experiences and projections, as well as through the heuristics discussed previously. If past experiences with commercialization of similar technologies are perceived as a loss, participants will most likely be in a domain of loss and will eventually choose a riskier mode of commercialization. This might lead to inappropriate technologies being chosen and lead to further inefficiencies in commercialization of innovative technologies in the future.

Participants in a technology transfer partnership are faced with several viable strategies of commercialization, including licensing, creation of a spin-off, and venture formation. When faced with a choice between these options, the participants face similar cognitive challenges. Based on the risk framing of the prospective outcomes, participants may opt for an option with more certain outcomes in terms of payoffs or choose the riskier option. If the participants are in a frame of gains and do not want to undertake much risk, the safer option is licensing. Licensing therefore reflects a sense of risk-averseness on part of the participants responsible for commercializing a technology. Looking at the avenue chosen for commercialization may therefore, be quite instructive in understanding the mindset of the participants and their position in either the domain of gains or losses.

The choice of commercialization avenues may also provide an insight into the search process that participants have undertaken. If participants are operating under cognitive constraints and time pressures, they may not be able to undertake a comprehensive search for possible alternatives. In such cases, the participants may choose for an option that satisfies the minimum criteria. As a result, the choice may not be as profitable or economically beneficial as other available options.

One key group of participants in the technology transfer partnerships are entrepreneurs. The literature on cognitive underpinnings of entrepreneurship could provide a few insights in this case (see Forbes 2005; Busenitz and Barney 1997; Baron 2004; Zacharakis and Shepherd 2001; and Simon, Houghton, and Aquino 1999). Scholars studying the behavioural patterns of entrepreneurs in forming new start-ups have observed that these entrepreneurs are often located in a domain of loss. In addition, they are often found to rely on judgement heuristics, which allows them to make decisions quickly (Busenitz and Barney 1997, 11). Entrepreneurs are also

prone to having an overconfidence bias (Forbes 2005). These cognitive processes are deemed an essential component of the entrepreneurial ethos. Entrepreneurs are required to make judgements about the commercial viability of a product and possible avenues of exploitation under extreme time constraints and uncertainty (Buseniz and Barney 1997, 13-15). At the same time, however, these limitations can induce serious biases in the judgement process and expose the entrepreneur to flawed decisions.

4.4. Conclusions:

The participants in a technology transfer partnership, just like in any other institutional structure, are faced with cognitive limitations which may affect their decision making. The literature on behavioural decision making informs the analysis of participant behaviour in complex institutional situations. Behavioural theories such as bounded rationality and Prospect Theory are frequently employed to gain an understanding of participant behaviour. These theories suggest that individuals are unable to exercise complete rationality under complex situations, and their decisions reflect bounded rationality. The extension of this argument, as presented in both these theories, suggests that individuals cannot rationally analyze the available information and rely on heuristics to judge a given stimulus. Furthermore, decisions are dependent on frames of reference--individuals invoke different judgements based on whether they perceive the outcomes in a domain of losses or gains.

These findings from the behavioural theories can also be applied to the participants in technology transfer and commercialization partnerships, a sub-system of the broader innovation system. The participants in these partnerships are faced with similar cognitive limitations and as a result end up making flawed judgements under complex situations. Their capacity to make

judgements about participation in a partnership, the commercial viability of certain technologies, and possible avenues to be used in the exploitation of that technology are in most instances biased due to their cognitive limitations. However, these cognitive incapacities do not act alone in the decision making process. They are coupled with other exogenous institutional variables such as rules, community attributes, and biophysical conditions, as discussed in the previous chapter.

Five

Saskatoon Agriculture Biotechnology Cluster: A Case Study on Technology Transfer and Commercialization

Building upon the institutional and behavioural framework established in the previous two chapters, this chapter presents a case study to test some of the theoretical postulates of the framework. The previous two chapters have provided ample theoretical foundation to analyze the applicability of the framework in real situations. In order to test the theoretical postulates, a case study on Saskatoon's agriculture biotechnology cluster is developed. The case study analyzes recent attempts to develop technology transfer and commercialization partnerships between university, public, and private sector organizations. More specifically, it highlights the efforts to develop an overarching organization known as the Bio-economy Center of Commercialization and Research (BECCR). In order to develop the case, interviews were conducted with key organizational actors who were involved during the proposal development stages of the initiative. A study of the BECCR initiative along with a general overview of technology transfer and commercialization initiatives in Saskatoon cluster highlight some of the barriers in the development of technology transfer partnerships. More importantly, it allows the reader to understand the important role played by institutional structures and behavioural frames in the development of these partnerships.

The chapter begins with an overview of the state of technology transfer and commercialization activities in Canada, providing the reader with the necessary background in order to be able to understand the issue from a broader national context. It then briefly describes the attempts to develop technology transfer and commercialization in the Saskatoon cluster, including the BECCR initiative. Following these descriptions, the methodology and findings section presents the key areas that were explored during the interviews with key stakeholders of the BECCR project and the observations emerging from these interviews. These observations are then analyzed, linking the findings with the key theoretical postulates of the institutional and behavioural framework established in earlier chapters.

5.1. State of Technology Transfer and Commercialization in Canada

In a global economy, the contributions of a strong research and development (R&D) system towards achieving long-term economic growth and national prosperity cannot be ignored. Both in Canada and internationally, R&D and innovation are looked upon as central drivers of economic growth instead of as mere components of countries' national competitiveness strategies. There is a global consensus, reflected in most strategies on R&D and innovation, that universities play a critical role in national innovation systems, both as performers of basic and applied research and as providers of highly qualified personnel (HQP) for all sectors (Association of Universities and Colleges of Canada 2008, 3). Governments in OECD countries have increasingly focused on partnering with both universities and industry in their quest to promote innovation in the fields of science and technology. Collaboration and partnerships have become features in nearly all national R&D strategies (Association of Universities and Colleges of Canada 2008, 5). With an increased focus on public-private partnerships as a strategy for

promoting innovation and knowledge transfer, the expectations from academia have also increased.

Part of this process has also been driven by the growing complexity and costs of research. Some assert the research enterprise has become too large and complex to be managed by any one organization. Moreover, technological advances have created expectations that an increasingly wide range of problems can be researched and addressed in a more holistic fashion and at an accelerated pace. This adds to the expectations of knowledge mobilization and comprehensive applications of research. As a result, governments and academia increasingly view enhanced R&D collaboration as a necessary means to achieve economies of scale, address productivity gaps, strengthen knowledge mobilization and commercialization, and improve the overall well-being of the citizenry (Association of Universities and Colleges of Canada 2008, 4). This strategy is particularly important in Canada, which is a relatively small player in the global economy and where some argue both the public and private sectors do not have the capacity to carry out all the functions associated with a knowledge economy. This is at least partly reflected in the large share of R&D performed in the public sector and in universities and the relatively poor performance of the private sector. Consequently, governments have made it a priority for public sector researchers as well as academia to collaborate with the private sector to ensure that knowledge generated in these organizations can be translated into economic growth.

The increased focus on public-private collaboration is partly the result of the structure of Canada's R&D effort. . The AUCC reports that in 2007 approximately $29 billion was invested in research in Canada, a modest overall increase of only 4.5 percent since 1992. By 2008, the OECD and the Canadian academies confirmed that the public sector has moved into the top five nations in terms of its basic research activities and outputs. The biggest concern of many is that

the private sector in Canada contributes only modestly to R&D investment. Canada relies relatively heavily on research in universities and public research facilities. Hence, it is particularly important for Canada to figure out how to efficiently and effectively commercialize technology and products from public institutions (Association of Universities and Colleges of Canada 2008, 1).

There is corroborating evidence that while Canada has a strong potential for basic research, both public and private Canadian institutions have not been able to tap into this potential, often failing to translate basic research into marketable, commercially viable innovative technologies. In 2003, for example, the revenue received by the 121 organizations from commercialized IP was C$55.5 million only. While this figure may sound large in absolute terms, when translated into net return on investment it represents a scant 0.44% net return (Smyth 2006, 5). This paints a rather bleak picture of technology transfer and commercialization activities in Canada.

One possible explanation for this weak performance is Canada's inability to construct institutions that can effectively translate basic and applied research from public labs and universities into the private sector. The rest of this thesis examines one attempt to construct such an institution and assesses the reasons for its failure.

5.2. The Saskatoon Agriculture Biotechnology Cluster

The Saskatoon-based agricultural biotechnology cluster is one of the most advanced and one of the few dedicated agriculture biotechnology clusters in the country. While the cluster may have developed a profitable niche in agriculture biotechnologies, Saskatchewan trails other clusters in terms of firms, revenues, R&D investment, and number of employees.

Dobni and Phillips (2001) have suggested that the source population for the Saskatoon cluster is roughly comprised of 110 actors. Of these, public research institutions (universities, government research labs) represent the greatest portion of the source population (35%) followed by private sector firms (34%), development and non-profit coordinating organizations (9%), and government entities (7%) (Dobni and Phillips 2001 quoted in Phillips et al. 2008, 243). In another study, Phillips et al. (2005) suggested that the most important of these organizations can be organized based on their density and centrality within the cluster (Phillips et al. 2005, 70). Based on these density and centrality measures, the authors have argued that University of Saskatchewan (UofS), National Research Council's Plant Biotechnology Institute (NRC-PBI) and Industrial Research Assistance Program (NRC-IRAP) are the central actors for R&D activity. NRC-IRAP was found to be the central actor in services and financial exchanges as well as high-quality personnel exchange and networking activities. Saskatchewan Research Council (SRC) and Ag-West Bio (AWB) were found to be main actors in these activities along with NRC-IRAP (Phillips et al. 2005, 74). It is interesting to note that the study did not find any private sector organization to be playing a central role within the cluster. All of the organizations listed were public, quasi-public, or collective organizations. Despite the presence of many well established and well connected organizations with competencies in many different areas of innovation, the commercial potential of technologies developed by these organizations has remained largely unrealized. These organizations provide a strong public sector research capacity, but their performance with commercialization and technology transfer has been deficient. There remains a gap between research and economic capacities. There is a strong realization at the governmental levels as well as within academia that action needs to be taken in order to fill this void.

From a historical perspective, various efforts have been undertaken in the Saskatoon-based Ag-biotech cluster in order to establish partnerships between academia, public, and private sectors. Most of these efforts have been concentrated around niche areas related to canola and pulses. In both these cases, actors from academia and the public and private sectors have played an active role at various stages including research, development, and marketing.

In the case of canola, Phillips (2001) has argued that since the inception of research efforts in this field, there has been a change of direction in collaborative activities (Phillips and Khachatourians 2001, 58). It has been suggested that the leadership role in the field of canola has evolved from public-based organizations to private sector corporations. In a sense, the leadership role has moved in patterns between 1944-1966, 1967-1973, 1974-1989 and 1990-1998 (Phillips and Khachatourians 2001, 65). These shifts were representative of attempts to fix various perceived or actual imperfections in the underlying dynamics of the canola value chain.

Despite these evolving patterns of leadership, the overall collaborative activity between academia, public, and private sector had remained focussed on the a strictly defined objective of developing and marketing double-zero rapeseed (what was ultimately named canola). The initiative was supported by a tightly knit community comprising public sector plant scientists and chemists from AAFC, the NRC, and a number of universities, with only a small amount of effort by a few selected Canadian companies. The community was also supplemented and supported by various farmer-led commodity groups. The state acted as a low-key facilitator and leader since the inception of the initiative. It also provided consistent and flexible funding and oversaw an open regime of IP policies. It can be argued that active public sector leadership led to the successful development and adoption of canola in 1960-78 periods and also provided for the right market conditions for the private sector to smoothly takeover the leadership role in the 90s.

The second wave of innovation related to canola saw efforts concentrated on development of more advanced commercially-oriented herbicide-tolerant varieties. This initiative was undertaken between 1980 and the late 1990s and built upon the earlier Saskatoon-based efforts to develop and adopt the original canola varieties. The introduction of private research into the canola industry after 1985 caused the seed business to significantly change (Phillips 2002, 4). As a result of this transformation in leadership roles, the private sector now controlled the majority of the research and commercialization process. Public entities played more of a supplemental role by engaging in partnerships with the private sector and providing support in the form of star researchers, public research facilities and research funding through tax credits and subsidies. The system was increasingly defined by a strict commercial focus which entailed exploitation of Canadian and global markets, development of commercially-funded research enterprises, and rigid IP structures. The initiative can be considered an overall success based on the data on the growth in herbicide tolerant canola acreage as well as a net cost-benefit analysis (Phillips 2002). Phillips estimates that the large capital investments were recouped within 5-7 years of product introduction, which justifies the decision to develop the technology (Phillips 2002, 16). Nevertheless, this success should be carefully qualified in the light of uneven gains across farmers, innovators, producers, and consumers (ibid).

In addition to canola development and commercialization, the Saskatoon cluster has also maintained a strong focus on innovation in pulses. The cluster has been responsible in developing and disseminating numerous varieties of pulses across the globe. These efforts to produce and adopt new varieties of pulses have also largely taken a collaborative form between a diverse range of actors from various public, private, community-based and academic organizations.

Partnerships have played a significant role in the production and adoption of new pulse varieties. In this regard, partnerships between the Crop Development Corporation (CDC), a University of Saskatchewan based entity, and the Saskatchewan Pulse Growers (SPG) can be considered an example of well-functioning partnership that is used as an exemplar across the cluster. A recent study by Ryan, Phillips, and Boland (2011) found the CDC-SPG partnership to be a unique case in that it is the top ranked actor and a highly connected gatekeeper controlling the flow of new information into and across a global research network.

More recently, the University of Saskatchewan undertook an initiative in 2007-8 to create a new technology transfer partnership in an attempt to consolidate the cluster's commercialization activities and re-invigorate public sector leadership in the cluster. The initiative, led by a few key researchers in the College of Agriculture, was driven in part by a funding opportunity. The National Centers of Excellence (NCE), a federal government funding program designed to promote commercialization and research, issued a call for centres of excellence for commercialization and research (CECR). The driving idea behind the effort in Saskatoon, named The Bio-Economy Center of Commercialization and Research (BECCR), was:

> to establish an innovative demand-pull entrepreneurial business/multi-institution research partnership with proven economic impact in bridging the industry/research commercialization gap through novel approaches to technology commercialization, wealth creation and skill development (Isaac 2008, 2).

The proposed center was a response to the pressing need for synchronizing commercialization activities within the cluster and among the leading public and university research units. It was envisioned that such a center would act as an anchor to the regional innovation cluster. Through this center, the lead actors planned to bring together the main organizations in the cluster including: the University of Saskatchewan (UofS) (especially the College of Agriculture);

Agriculture and Agri-Food Canada (AAFC); the National Research Council- Plant Biotechnology Institute (NRC-PBI); Saskatchewan Research Council (SRC); Canadian Light Source-Synchrotron (CLSI); Protein, Oil, and Starch (POS) pilot plant; Feeds Innovation Institute (FII); Ag-West Bio (AWB); and Innovation Place Bio Processing Center (IPBPC). The center would draw upon the strengths of all of the stakeholders in the cluster to optimize economic development. By bringing these organizations together, it was argued, the center would enable the private sector to identify problems, needs and challenges, and then draw upon the research capacity of the partnering organizations to facilitate solutions (Isaac 2008, 3).

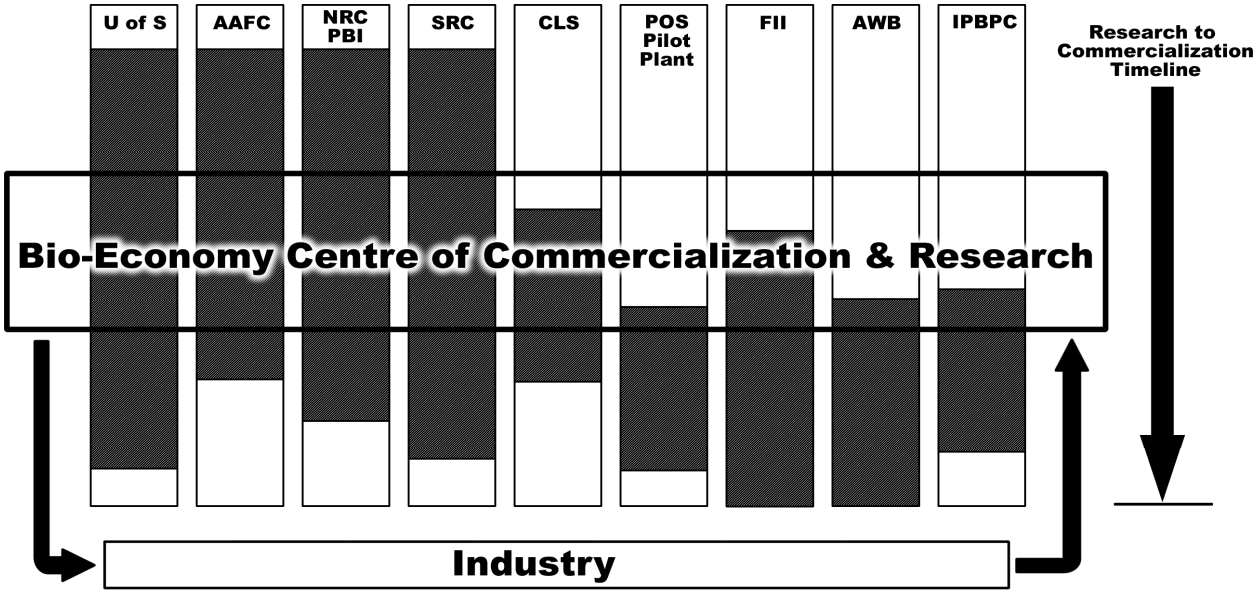

Figure 5.1. Central Stakeholders in the Saskatoon Bio-Economy Cluster

Source: Isaac 2008, 4.

Figure 5.1 shows how each of the organizations or institutions were engaged in bio-economy research or commercialization. The shaded area within each of the pillars represents the stage of activity within the bio-economy (Isaac 2008, 4). The BECCR, as the figure shows, was

envisioned as the cluster anchor which would horizontally bridge each of the distinct pillars of capacity within the cluster (Ibid).

The main goal of this partnership, as outlined in the proposal, was to bridge between major research organizations "to provide a seamless management of intellectual property, research contracts and projects which will provide much improved research efficiency and commercialization for the private sector" (Isaac 2008, 4). Furthermore, it was argued that such a center would facilitate the creation of public-private partnerships, engage industry throughout the innovation cycle, and improve risk management and research productivity. Consequently, the proposal indicated a strong emphasis on supporting entrepreneurial activities and assisting small and medium sized business and large industries (Ibid).

The proposed center, however, failed to materialize after an unsuccessful attempt to secure NCE funding. The idea has been discussed extensively within the cluster and it provides a good starting point to understand some of the institutional and behavioural factors that have been postulated as critical in determining the successful development of such technology transfer and commercialization partnerships. In the following sections, we develop a case study to demonstrate how various institutional and behavioural factors had (negatively) influenced the development of this particular project. The case study also helps us distinguish between the more successful partnerships that have been established to develop and commercialize varieties of canola and pulses.

5.3. Methodology and Findings

To capture the underlying dynamics of developing technology transfer and commercialization partnerships between the three organizational spheres, open ended, in-person

interviews were conducted with 15 key individuals who were involved with the BECCR initiative as well as other such initiatives in Saskatoon. These individuals are affiliated with various organizations in the Saskatoon cluster including University of Saskatchewan, NRC, Ag-West Bio, CLS, and various others. The survey design and method was assessed by the University of Saskatchewan Behaviour Research Ethics Board (Certificate of Approval BEH # 09-256), which can be found in the appendix).

The main expectation from these interviews was that they would offer a test of the theoretical postulates of the framework developed in previous chapters. Therefore, the questions were developed to capture and analyze the institutional and behavioural underpinnings that affect the development of technology transfer and commercialization partnerships, specifically the BECCR initiative. Table 5.1 provides the list of questions participants were asked during the interviews.

Table 5.1. List of interview questions

1. Describe the process that was undertaken to develop the BECCR initiative?
2. What goals did you expect to achieve through the use of this particular partnership?
3. What was the role of your specific organization within this proposed partnership?
4. What were your individual responsibilities within your organization in regards to this partnership?
5. In your view, what are some key factors that are required to develop a partnership like this one?
6. What were some of the strategies or channels that were used in the efforts to develop this partnership?
7. What were some of the impediments to creating this specific partnership?
8. Does the rhetoric of common interest between the parties mask important differences of value and motivation?
9. What role did the individual faculty members play in this process?
10. Are there lessons to be learned, which can also be generalized to other cases?

These open-ended questions were only used as guides for the discussion and were not always presented to the interviewees in the same order. While the responses to questions related to institutional factors provided more direct insights, those corresponding to behavioural factors provided a bit of a challenge. These responses only indirectly reflected on the cognitive domains of individuals. Therefore, we had to look out for key terms used by individuals as an indicator of their relative cognitive domain at the point of decision making during the initiative. In our presentation of these findings, we have developed a list of descriptors which allow us to distinguish between cognitive domains. These descriptors are presented in table 5.2, with more

detailed descriptions of these presented in section 5.4.2. We also highlight the key words which were used by the respondents to stress a certain position by putting them in quotations ‘’.

Table 5.2. Descriptors of Cognitive Domains of Gains and Losses

Domain of Gains Indicators	**Domain of Losses Indicators**
View cluster as performing well	Concerns about the loss in the leadership position of the cluster
Organizational success with commercialization	Past failures in commercialization experience
New discoveries	Sense of urgency
Personal career success	Entrepreneurialism

Source: Author.

The interviews yielded some very interesting (often conflicting) observations. These findings reflect the individual and organizational views and experiences of the respondents as they relate to the specific BECCR initiative as well as other efforts to develop technology transfer and commercialization partnerships in Saskatoon cluster. At one level there appears to be a clear distinction between perceptions and experiences of those involved with technology commercialization from within the university and those who are in other public sector organizations within the cluster. More divergence in views is also found within the university as compared to between the other public sector organizations.

Broadly speaking, individuals were rather cautious and a bit sceptical about the prospects of the BECCR initiative. The majority of the interviewees displayed negative views about the concept and were highly sceptical that it could work. One view held by some individuals was

that the idea of pooling patents in the cluster was premature; the individual organizations were either not advanced enough to enter a collaborative venture of this scale or were not willing to relinquish their IP portfolio to a third party. Others more broadly viewed the idea was `naive` and too simplistic for the complex world of agriculture biotechnologies and innovation in general. Furthermore, some believed that an entity like BECCR would introduce yet another layer of bureaucracy to a system which is already fraught with bureaucratic complexities. Altogether, the general opinion across the board seems pessimistic and sceptical towards this initiative.

The observations presented here can be mapped onto the institutional and behavioural frameworks presented in the previous chapters. In order to do that, the themes are re-packaged into the narrower themes of institutional and behavioural factors as they affected the BECCR initiative. While some of the factors may not fit neatly within the institutional and behavioural frameworks, nevertheless they can extend understanding of technology transfer partnerships and possibly create venues for modifications to the framework in the future.

Size of the economy and receptor capacity, federal and provincial politics, rules and formalization, time frame, faculty involvement, IP policies, ILO structure, University policies and administration, organizational culture, and leadership are the sub-themes identified here which can be grouped under the IAD umbrella. Findings categorized under framing and the win-loss mindset, motivations, entrepreneurial spirit, general perceptions, and definition of goals and their interpretations can be re-grouped under a comprehensive category called behavioural factors. Analyzing these factors extends understanding of how different cognitive models influenced decision making within the cluster.

A closer look at the sub-themes identified in the previous section reveals that these themes directly or indirectly correspond to the main features of the institutional analysis framework presented in chapter two and can be analyzed as such. Economy size and receptor capacity, leadership, and the governments' role can be classified as the enabling biophysical material conditions, whereas trust and relationships, organizational cultures, university policies and administration, ILO structures, and time frames can be considered part of the community attributes. Rules and formalization can be used to inform the 'rules' component of the institutional framework. As chapter two highlighted, biophysical and material conditions, attributes of the community, and rules are the exogenous variables which determine the interactions between the participants and the action arena. In the analysis section, we analyze these findings from the IAD and behavioural perspectives in greater depth.

5.3.1. Institutional Factors

Federal and Provincial Politics: Some respondents, especially the project leaders, were sceptical of the role played by the federal and provincial governments in promoting technology transfer and commercialization partnerships. In the case of BECCR, project leaders argued that while governments were slightly interested in the idea they never really took the responsibility to follow up on it. The political will and leadership to support the initiative whole heartedly were absent.

Size of the economy and receptor capacity: It was noted in the literature and some studies that the small size of Saskatchewan's economy and a lack of receptor capacity in the private sector could be contributing factors towards the sub-par performance of technology transfer partnerships in the province. However, this factor was notably much smaller and did not feature

prominently in the interviews and discussions. As a matter of fact, some respondents even argued that Saskatchewan has the necessary resources; yet has not been able to utilize the resources to translate innovative activity for its economic progress.

Rules and Formalization: Opinions on the impact of institutional factors on the success or failure of technology transfer and commercialization partnerships were mixed. It was generally asserted that the BECCR did not proceed to the level where it could be institutionalized because it failed to secure NCE funding. Consequently, there were no attempts to institutionalize it beyond the proposal development stage. To the extent that the proposal and underlying negotiations represented an attempt to institutionalize commercialization of technologies from within the cluster, many respondents felt that these attempts were insufficient.

One commonly held view was that the initiative tried to adopt a 'revolutionary' approach rather than an 'evolutionary' approach. The initiative tried to define a broad set of areas for collaboration and consequently ended up being too abstract. By trying to encompass a broad set of technologies including crops, microbes, animals, and nutrition all in one package, the initiative failed to focus on one core area which could have provided the impetus for expansion at later stages. The initiative did not reach a level of specificity which would give players the certainty that is required for such partnerships. In other words, the BECCR initiative did not define the 'scope' of its activities.

Furthermore, it was argued that the suggested membership for the project was too broad. Respondents suggested that inclusion of too many organizational players with diverse interests may have complicated the negotiations over the roles of each proposed participants. The respondents were of the view that in order for such partnerships to be successful, they need to be

'evolutionary' rather than 'revolutionary' and start by taking small pieces and building on them instead of adopting a comprehensive approach. According to the respondents, lack of specificity along with absence of high level vision and clear definition of end goals were the key institutional factors which created impediments for BECCR initiative.

Generally, the respondents did not view formalizing the institution as an extremely important step in the early stages of the partnership development process. Even those who considered institutional factors an important part in developing commercialization partnerships tended to argue that institutional factors rank behind developing trustworthy and long-term relationships among the stakeholders. Nevertheless, they pointed to some successful cases in the Saskatoon cluster where institutionalizing the partnerships have helped these partnerships develop and grow over the years. Two successful models that were frequently referred to by the respondents were the NRC-PBI research collaboration model and the U of S Crop Development Center (CDC) partnership with the Saskatchewan Pulse Growers (SPG). In both these cases, clear rules of engagement have been established and enforced. The scope of those ventures is clearly defined, financial arrangements and revenue sharing schema clearly drawn, and training provided to the participants around their protocols for engagement. In addition, these models set out rules for information sharing and membership, as well as a very specific set of technologies that are to be commercialized. In both cases, however, the scope was narrow and the number of participants limited to those with clear interests in the specific partnership.

Organizational Cultures: All the respondents agreed that different organizational cultures were a definite barrier in developing the technology transfer partnership. The widely held view across all the organizations is that indeed the organizational cultures of the university, the public sector and private firms differ significantly. Each organization has a different set of values,

organizational goals, and expectations. These differences become more problematic when the partners fail to understand, or even worse when they do not even attempt to understand, the culture(s) in other organizations. Respondents also spoke to the different (institutional) 'languages' as a barrier. This difference in languages makes it difficult for the partnering organizations to effectively communicate. Consequently, the three organizational spheres fail to understand and respect the requirements and constraints of each other. The lack of understanding of each other's organizational culture can often times lead to misperceptions and a sense of competition between the partners, which can contribute to failure of the partnership initiative. In the BECCR case, respondents noted that one reason they were sceptical about the idea was they feared that organizational difference could not be easily overcome.

Leadership: One of the many observations respondents made regarding the failure of BECCR and similar initiatives was the lack of effective leadership within the cluster. It was argued that no one emerged as a legitimate leader despite many individuals expressing willingness to lead. One of the reasons for the lack of leadership was the internal competition across the public sector organizations where everyone was more concerned about their own organizational domain and issues that fell under that domain. For example, respondents from the public sector organizations like NRC-PBI and AAFC believed that they were most suitable leaders whereas the university was looked upon as more of a secondary actor. When the university actors failed to secure the federal funding, which was considered the main motivation, the so-called 'champions' moved away from the project. In addition, some argued that the university itself was going through administration renewal—searches were underway for vice president research and associate vice president research, there was an acting dean for the college of agriculture and a decanal search and a new provost had just been appointed—which stifled the momentum of the BECCR project.

These major changes at the administrative level caused a lot of uncertainty and those who were at the helm of developing the proposal no longer remained associated with the initiative. Meanwhile, there were no engaged industrial actors. Consequently, all three spheres failed to find committed leaders who could find legitimacy within the cluster.

Time frame: A few respondents noted that the effort to create the BECCR was running against the clock. Prospective partners felt that there was not enough time to establish a formal entity like BECCR given the complexities of issues and the authority chains involved. The stakeholders, it was argued, did not get enough time to discuss what each would be able to bring to the table. As an afterthought, one respondent claimed that given more time, the project could have been successful despite being unable to secure the funding opportunity.

University policies and administration: The University culture, many argued, still reflects a public-knowledge mentality, which does not easily accept the involvement of private sector on the campus. University policies and attitudes of senior administration were considered one of the biggest barriers in establishing a three-pillar partnership between academia, public research labs and the private sector. One of the biggest barriers was arguably the bureaucratic hurdles at the university. Lack of flexibility and speed, respect for other organizational partners, and a failure to understand the needs of the partners were identified as the key barriers created by the university. It was further suggested that the university does not understand the entrepreneurial and innovation culture; it is very conservative, inward looking, and protective of its technologies.

One concern raised about university commercialization plans is that it is commonly viewed as a potential major source of revenues. Many respondents argued that such a view is extremely narrow. At the same time the university also has contradictory policies around tenure track,

consultation time, and private sector research funding. For example, one faculty member interviewed noted that the university collective agreement only allows twelve days of consulting work per year. Any extra time devoted towards consulting leads to a claw back in the salaries, which acts as a disincentive for many university researchers who are involved in or would like to be involved in technology transfer and commercialization activities. On a more general level, most respondents argued that these problems are not just confined to University of Saskatchewan; rather they are found at a more systemic level across most Canadian universities and even in the public labs.

Industry Liaison Office (ILO) structure: Some respondents pointed to the ILO structure and hiring practices as a core part of the problem. With the BECCR initiative, it was noted that the ILO was not involved in starting it and remained largely disengaged from the process. One interpretation was that ILO was very sceptical of the idea behind BECCR as it would probably lead to it losing substantial control over its IP portfolio.

During the interviews, individuals commonly referred to the ILO's hiring practices as 'misaligned.' Respondents argued that ILO has a history of hiring accountants and lawyers to manage the IP portfolios and then puts them in-charge of negotiating with other public and private sector actors. These individuals were viewed as not well versed with the scientific content of innovative technologies, with the result that some felt they might not be able to make the right decisions about a technology's scientific and commercial value.

Faculty Involvement: When asked whether faculty/researcher involvement in the commercialization process in any way facilitates the partnership development process, the responses were mixed. Some argued that faculty involvement in the actual process is not

necessary; the role of the researcher is simply to develop new technologies, products and services. These individuals argued that researchers are not really and should not be the drivers of the commercialization process. One respondent suggested that researchers only care about their funding and are not really concerned about the outcomes of technology transfer and commercialization. A number of respondents noted that most researchers at universities and public laboratories are not professional inventors: they lack a market sense as well as the networking capacity to work with the private sector.

Others respondents, however, viewed researcher involvement as vital. These respondents argued that researchers possess tacit knowledge which can be extremely valuable during early commercialization, especially at the prototype development stage. One of the respondents pointed to the NRC-PBI model, which allows firms to co-locate with researchers during the early phases of a transfer partnership. It was observed that many firms (such as those engaged with NRC-PBI) were keen on working closely with public sector researchers and were willing to pay a premium for the services of those researchers. Respondents who viewed faculty involvement as an important factor in the development of technology transfer partnerships noted that researchers, especially university researchers, are often encumbered with burdensome university regulations which make it almost impossible for these researchers to participate effectively in any such activity. As a result, these researchers often end up bypassing the ILO and relevant authorities and tend to deal directly with the private sector.

5.3.2. Behavioural Factors

Goals and their interpretations: The interviews revealed that individuals had different goals in mind for the BECCR initiative. The interpretation of these goals as well as the means to

achieve them also varied significantly across the respondent pool. Some of the more consistent observations about the goals of the BECCR included: establishing a central commercialization mechanism, promoting economic development, achieving a critical mass, and enhancing efficiency. University administration and the project leaders mostly viewed BECCR as a platform which would provide a common base to commercialize bio-science innovations and enable the stakeholders to develop, nurture, set priorities, make decisions, and mobilize funds and resources in support of commercialized technologies. While that intermediate goal may have been generally accepted, the ultimate payback was less clear. As one individual highlighted, the objective was not to create patents and generate royalties for the university; rather it was to attract investment, companies, and research dollars for better graduate training. Given that individuals mentioned different goals and payoffs, the only consensus across the group was that participants had a lack of agreement over the goals and their interpretations. Participants were of the view that the lack of agreement could possibly be attributed to lack of a common vision and leadership around this particular initiative.

Motivations: While the main intent of the questions was to inquire about the intrinsic motivations each of the individual participants held, the responses tended to reflect the organizational, extrinsic motivations rather than individual motivations. The majority of the participants were of the view that the primary motivation behind the initiative was to tap into the funding that had become available through the NCE funding call. Others viewed it as an opportunity to secure Saskatchewan's leadership position in the area of bio-economy and to be able to introduce and mobilize innovative technologies into the economy. While on paper these could be consistent, in practice they have divergent timelines and beneficiaries.

Trust and Relationships: There was almost unanimous consensus that trust and relationships were critical to partnership initiatives like BECCR. Establishing a trust-worthy relationship with all the potential partners is considered a necessary prerequisite to the development of such partnerships. A number of respondents pointed out that the private sector places extremely high value on developing relationships with research organizations and that once those relationships are established firms are willing to go a long way to maintain those relationships even if they do not provide immediate economic returns. It was suggested that trust and relationships should be developed and nurtured prior to any attempt to agree upon formal rules of engagement. Respondents also agreed that trust and relationships cannot be imposed from outside –they need to grow organically. Partners need to be respectful of each other's organizational culture, while communicating to find a common vision. It was argued that in the absence of effective communications, misperceptions could arise between partnering organizations which could prove detrimental to the long term prospects of establishing a healthy relationship.

Framing and the Win-Loss mindset: Given one of the focal points of this study is the behavioural models and cognitive limitations of participants in a technology transfer and commercialization partnership, this theme features as one of the most important parts of the analysis. Questions 4, 8, and the follow-ups to these questions were used as triggers to judge the cognitive models potentially employed by the participants.

The findings suggest that individuals leading the BECCR project were possibly in a domain of loss. These individuals suggested that they were 'concerned' about the Saskatoon cluster's position as the leader of innovative technologies. The understanding among these individuals was that Saskatchewan had 'squandered' its lead. They felt that the cluster was 'underperforming' in terms of moving technologies to commercialization and especially was

'falling behind' in promoting commercialization of value added technologies. Consequently, these individuals tended to see the NCE funding opportunity as an ideal situation to kick-start the BECCR project. However, they also pointed out that while they felt a sense of 'urgency', they were aware that partners from other public sector organizations definitely did not share that sense of urgency.

Respondents who belonged to different public sector organizations tended to convey that there was no sense of urgency on their part. They believed that organizations were 'functioning relatively well' at the individual level, and even though everyone would like to see some improvements, the overall cluster is not 'dysfunctional.' As a result, there was no overriding reason for the organizations to collaborate, apart from the funding opportunity. In short, they were risk averse and wanted to see real, tangible benefits before they committed further to the partnership.

Another aspect of these conversations which revealed a risk-averse attitude of the partnering organizations was their win-loss mindset. Almost all the respondents noted that there was a definite win-loss mindset across the organizations that were involved with this project. Respondents generally agreed that all the organizations have a lot riding on whether or not they can successfully commercialize their technologies and to hand this function to a third party was a risk these players were not willing to take. They were concerned that by doing so they would lose their authority, their IP, and the potential revenue streams. The organizations, it was argued, had a 'scarcity mindset,' which forces them to compete for the limited funding and revenue opportunities. One respondent suggested that it was 'naive' to imagine a scenario for this initiative where the proposed partnering organizations would not compete for the limited resources. Some respondents argued that the organizations have not yet advanced to that stage

where they are psychologically ready to share resources on anything other than a project-by-project arrangement. The 'give-get' mentality identified by respondents was judged to be a major road-block to developing a partnership like BECCR.

One respondent made an interesting observation: during the time when BECCR was undertaken, the university had an acting vice president research, an acting associate vice-president research, an acting dean and associate dean of agriculture, a soft money researcher, and a new provost all involved in one way or another with this venture. All these acting/new appointments had limited mandates and it was suggested that they needed a quick or early win to solidify their positions. Alternatively, it was suggested that some contingent appointees, especially those who think incumbency vests them with more ownership in a position, might be in a loss framing and thus be unwilling to undertake a risky initiative, which, if it had gone wrong, would jeopardize their credibility. The survey results were not granular enough to enable us to define whether the status of the individuals influenced their win-loss framing.

Entrepreneurial spirit: The respondents viewed the entrepreneurial spirit and ethos to be a very important factor in establishing successful commercialization partnerships. However when asked whether researchers need to be entrepreneurial or not, the views were mixed. One view was that researchers do not necessarily need to be entrepreneurs as long as someone in the partnership has the entrepreneurial skills and is familiar with the intricacies of markets. Others viewed it as a difficult proposition for researchers to engage in entrepreneurial activities because it is a clash between accountability, control, and entrepreneurialism. These individuals argued that entrepreneurs are fundamentally risk takers, whereas the requirements of accountability imposed by government and the university act to counter the entrepreneurial spirit. These regulations, which allow the administrators to control inputs and outputs, end up negatively

affecting the technology transfer and commercialization outcomes one might expect from the initiatives such as the BECCR.

5.4. Analysis

5.4.1. Institutional Factors

Attributes of the community seem to have played a decisively negative role in the development of BECCR initiative. Different organizational cultures, as hypothesized in the previous chapters, have acted as a key impediment in this case. Furthermore, the organizations involved in developing these partnerships show no particular interest in understanding and respecting each other's culture. In this regard, rigidness of the university's organizational culture, which has been regarded as 'unsupportive' and laden with bureaucratic hurdles, was presented as the biggest barrier. Interestingly, similar sceptical perceptions are held by university administrators of other public sector organizations and the private sector. Such divergent attitudes towards key organizations within a partnership point to a state of disarray within the cluster. While all the key players recognize the differences in organizational cultures and stressed the need for an understanding and respect of each other's culture, they were unable to realize that goal in the BECCR exercise. Rather, it would appear that extending 'soft' co-operation through long term communications and relationship building exercises may be the best way to build meaningful and effective technology transfer and commercialization partnerships. In this regard, longer time frames for development may be critical. Quick, purpose built processes appear to have high returns but are not enough to create long-term trust. Repetitive interactions over time, some argued, may ultimately enable the participants in these partnerships to develop trust and achieve a common understanding of the goals.

Biophysical and material conditions, which we define as political leadership and receptor capacity, were also not favourable for BECCR. These two factors are complementary, as the absence of one could mean absence of the other. For example, if governments are not willing to show their positive intent to encourage private sector firms to actively take up innovative technologies emerging from the public sector and universities, it sends the wrong signal to the private sector. Alternatively, an absence of strong private sector receptor capacity may act as a disincentive for governments to take public sector technology transfer and commercialization activities seriously. In the case of BECCR both these factors were clearly missing which hampered its development and led to its quick demise after the failure to secure NCE funding.

The other key institutional impediment has been the lack or poor design of rules. Position and boundary rules in the case of BECCR were broadly defined, allowing a wide range of organizations to act as participants in the proposed partnership. In the case of position rules, power structures were not defined in a way which would account for the horizontal nature of the project. Consequently, there was a lot of ambiguity over the ownership of the initiative. Boundary rules were also defined in a way that would allow the participating organizations to remain partners for as long as they wished. In the absence of well-defined boundary rules, the leadership for the partnership was ill defined and the initiative subsequently suffered due to the lack of 'champions.'

Another important feature was the absence of authority and aggregation rules along with a lack of proper communication channels. Failure to devise these rules during the process of establishing the partnership constrained the ability of partnering organizations to effectively set the direction for the collective venture. The choices of these participants were further limited by the key role of patent pooling for the centre. The strong focus on IP and unwillingness on the

part of the organizations to transfer the ownership of these patents to a third party organizational structure like BECCR proved a strong road block in establishing the partnership.

The patenting strategies adopted by the partnering organizations also created barriers in defining the payoff rules. Lack of agreement on payoff rules was judged to affect the willingness of partners to contribute to the partnership and prevented them from wholeheartedly accepting the notion of collaboration. As the findings suggest, university policies towards faculty involvement in commercializing activities (salary claw-backs and limits on consulting time) have also had detrimental effects on the motivations of these individuals to participate in commercialization partnerships.

However, this last finding needs to be carefully qualified. Salary claw-backs and limits on consulting times are not directly related to commercialization activities; rather they represent a more indirect linkage. At the same time, consulting may be considered by researchers as an important step in building relationships with private firms and other partners. Both the literature review and the interviews conducted as part of this exercise confirm the importance of long-term relationships in the establishment of successful partnerships. Therefore, placing limits on these activities may create a disincentive for researchers to reach out to potential partners and hurt the efforts of building successful long-term collaborations.

Another important aspect from these responses was the broad and ambiguous definition of the technologies that were to be pooled through the BECCR. The two cases of NRC-PBI and CDC-SPG highlighted earlier provide a perfect counterfactual. It can be argued that the broad definition of technologies and the diverse array of potential participants made it difficult to confine the problem at hand to one action situation. Consequently, there were many overlaps

with other action nodes and action arenas, which arguably made it difficult for the project leaders to define the rules in a clear and coherent manner. In addition, the levels of analysis were blurred because of the poorly defined scope of technologies. The clarity of rules suffered because of their embedded status in multiple levels of analysis. In other words, rules at each focal level were influenced by rules at other levels. As deduced through the discussion on the IAD framework, lack of a clear problem definition quite likely played an important part in blurring the relationship between rules and level of analysis, making it difficult for the project leaders to analyze the implications of these rules in isolation from their broader application.

A summary of institutional variables as they were laid out in the case of BECCR and partnerships established in the cases of canola and pulses is presented in Table 5.3. This comparative table helps us understand the underlying differences in these factors and their ultimate impact on the outcomes of these partnerships. It should be noted that the institutional factors in the case of canola and pulses partnerships have not been identified through an extensive case study like the one conducted for BECCR; rather they emerge from previously undertaken studies on the Saskatoon based Ag-biotech cluster.

Table 5.3. Comparison of Commercialization and Technology Transfer Partnership initiatives in Saskatoon Cluster

	BECCR	**Rapeseed to Canola**	**HT Canola**	**Pulses**
Action Arena	Broad definition of the problem, different interpretations of goals, different cognitive framing of the issue at the individual level	Narrow definition of the problem; common goal of producing and adopting double-zero rape	Sharply focused commercial problem; competition between four competing research efforts	Broad definition of the problem; common goals of producing and adopting new pulse varieties shared globally
Attributes of the Community	Diverse community, comprised of various public sector and university researchers as well as senior administration	Narrow community of public sector plant scientists and chemists, supplemented with farmer -led commodity groups and supportive supply chain	Corporately controlled research and commercialization, supplemented with public-private research partnerships that engage star scientists	Diverse community of public sector plant scientists and farmer-led commodity groups networked to global system
Biophysical and Material Conditions	Absence of political support , lack of economic receptor capacity, lack of leadership, and pressed for time in terms of funding opportunity, rigid IP policies	State as low-key facilitator and leader; open ended effort; flexible funding and open IP policies	Commercial systems focused on exploiting Canadian and global markets; proprietary systems; commercial funding and rigid IP structures	Blend of public and proprietary research and commercializati on; large and diversely connected community of funders, researchers and marketers
Rules	Vaguely defined, broad definition of membership and technologies to be commercialized, lack of agreement on payoff and scope rules	Relied upon open-science norms that were communally developed and sustained; vague yet effective payoff and scope rules	Clearly defined payoff and scope rules embedded in firms, supplemented by contracts to access and advance public science	Public-private partnerships with contractually managed payoff and scope rules; general reliance on commercial research payoffs combined with

				upon open-science norms
Outcomes	Unsuccessful; effort aborted after two years	Successful development and widespread adoption of canola in 1960-78 period; growth in industry to largest crop in succeeding years	Successful development and widespread adoption of HT canola in 1985-1999; 30% growth in acreage in succeeding years	Successful development and adoption of a succession of new pulse varieties and growth in industry to more than 5 million acres 1995-2011
Source:	Author.	Phillips and Khachatourians 2001	Phillips 2001; Phillips 2002	Boland, Ryan and Phillips 2011

5.4.2. Behavioural Factors

Problem framing and differences in cognitive domains of individuals seem to have played an important role in sealing the fate of the BECCR initiative. The most important difference identified was between the university and other public sector organizations. Even within the university, there were considerable differences in the cognitive domains held by the project leaders and senior university administrators. It can be argued that the university as a whole and the project leaders especially viewed the initiative from a loss domain perspective. Their view of the cluster's losing leadership position ('squandering the lead') was the primary driving motivation behind the initiative. Furthermore, the perception among the BECCR participants that the ILO has had little success in commercializing technologies appears to have played a role in placing the university participants in the initiative in a domain of loss.

Some university administrators, for different reasons, were at times in the domain of gains. As pointed out earlier, some senior administrators had recently been appointed to the acting

positions, especially the vice president and associate vice president research, who were organizationally responsible for representing the interests of the university in this partnership. Because of their contingent status and expectations of securing long appointment, these individuals appear to have been largely in the domain of gains. Consequently, they were less willing to take risks that might jeopardize their positions. Eventually, these individuals secured long term permanent appointments--had the project lasted until these individuals were able to establish themselves in their respective positions, one might expect them to take much bolder risk-taking steps.

The individuals representing other public sector organizations, however, did not view the cluster as threatened. These organizations tended to report that they were performing relatively better than the university in their technology transfer and commercialization functions—thus they framed the problem from a domain of gains perspective.

Similarly, it can be argued that many researchers were and often are in a domain of gains, especially after a successful scientific discovery. Their cognitive framing is often demonstrated through their high valuation of their inventions despite evidence that the real commercial value of any single invention is usually modest. As a result, many inventors are less willing to take risks by exposing their technologies to under developed markets. This negatively impacts their capacity to understand the market risks (they become averse to these risks), resulting in a lack of willingness to participate in commercialization activities.

A faculty member's cognitive framing can be used to explain the lack of entrepreneurial spirit in the science-based world. While it has been argued that these individuals are usually creative and entrepreneurial in their own fields of study, they do not exhibit a good

understanding of market dynamics and entrepreneurial spirit. As argued in the previous chapter, market entrepreneurialism requires individuals to make risky decisions which ultimately rest on the cognitive framing of possibilities in the loss category. Since the faculty members and other public organizations most often appear to be in the domain of gains, their propensity to be risk-seeking declines significantly.

Table 5.4. Key descriptors and cognitive domains of individuals in BECCR

Position	Key Descriptors	Cognitive Domain
Project Leaders	Viewed the cluster as 'underperforming'; concerned about "squandering the lead"	Loss
University Administrators	New administrative appointments less willing to undertake risky initiatives	Gain
Public Sector Researchers and Administrators	Organizations were viewed as 'functioning relatively well'; cluster was viewed as 'not dysfunctional'	Gain
University Researchers	New discoveries/innovations; Lack of market entrepreneurialism	Gain

Source: Author.

The broad definition of membership in the BECCR initiative could also have adversely impacted the cognitive domains of individuals. Individuals who were to join the initiative came from different academic and professional backgrounds. It can be argued that differences in norms across various academic disciplines shape the cognitive processes employed by individuals. For example, those trained in sciences use more deductive approaches in their decision-making whereas those from social sciences take inductive approaches—the BECCR involved scholars and practitioners from both fields. These differences in decision making approaches could also have an impact on individual's cognitive framing of a situation. While this cannot be confirmed in the surveys, the possibility remains.

The broad and expansive definition of technologies in the BECCR initiative may also have affected the decision-making processes of individuals. Since the project had envisioned including a broad and somewhat ill defined set of technologies, one can imagine that individuals associated with different technologies and products may be in different domains. Those working on pulses, for example, might be in a domain of gain as the CDC-SPG partnership was judged to be serving them well. Those who identified themselves with bio-fuel technologies, in contrast, might be in a domain of loss; efforts to develop bio-fuels are still in their infancy and have not met with much success. Consequently, one can expect researchers from the former group to have viewed the BECCR initiative as a risky prospect, with returns that would not be significant enough to offset their existing returns, while the latter group might be more disposed to engaging.

The differences in framing of the issue may also have negatively impacted the mindset of individuals involved in the partnership. Those who viewed themselves or their organizations as generally successful might be in a position of gains and be more concerned about the possible loss of their position or the loss of revenues which would accompany the transfer of their IP portfolio to BECCR. The survey confirmed that many of these individuals, and the organizations they represented, were sceptical of the idea behind BECCR, reflecting their risk-aversion.

Differences in cognitive framing can also be used to explain the divergence in the goals and interpretation of those goals by the participants. Individuals in a domain of gains appeared to envision the partnership as a mode to establish long-term trustworthy relationships with each other. Those in the loss domain viewed the partnership as a source of economic development accompanied by a healthy long-term revenue source for the university and possibly other partnering organizations in the cluster. These divergent views, along with lack of communication channels, and other factors described previously, contributed to the failure of the project.

5.5. Conclusions

While Canada has strong research capacity, it remains behind many developed countries in its ability to transfer and commercialize technology. While many technology clusters exist in Canada, their contributions to the economy have generally remained below par. Saskatoon's agriculture biotechnology and bio-economy cluster has had some success. Despite the strong presence of many public and private sector organizations, including the University of Saskatchewan, there remains a significant gap between basic research and commercialization. There have been many attempts over the last decade to improve this deficiency; however most of these attempts have been less than successful. The BECCR effort, presented in detail here, sought to develop a bio-economy center of commercialization and research. Through this attempt, the university and public sector organizations attempted to develop a common pool of commercially viable technology patents. The idea was to develop a central vehicle to commercialize the technologies generated in the community, by packaging them together. It was hoped that such an organization would provide an overarching system which would be more efficient and would attract more private sector uptake of these technologies. The project failed, likely for a variety of reasons. Most point to the failure to secure funding as the point of failure—while that clearly was a milestone in the effort, it in and of itself did not have to signal complete failure. In this chapter, we have attempted to present some of the underlying reasons which acted as impediment to the sustained development of the initiative.

The case study on the BECCR project, developed by conducting exploratory interviews, has provided insights into a range of institutional and behavioural factors. The analysis shows that the critical institutional factors were the exogenous variables (biophysical and material

conditions, community attributes, and rules) and the ill defined action arena. Within each of these categories, many sub-themes were identified which helped us to parse out the institutional details as they played out in the process.

The case study also offers an analysis of the behavioural factors which appear to have played a role in the process of establishing the commercialization partnership. The differences in cognitive framing of the problem have been identified as a main impediment in the development of this particular partnership. These differences appear to have led to a competition based on the win-loss mindset and caused a divergence in the understanding of goals and their interpretations. While this element has not been methodologically sophisticated, the brief analysis provides critical insight into the impediments that can be created because of different cognitive models employed in the formation of partnerships.

Six

Summary and Conclusions

This study has presented an institutional and behavioural framework for the analysis of technology transfer and commercialization partnerships. Based on the literature review and the theoretical framework presented in chapters three and four, a case study has been developed to analyze a specific partnership development effort in the Saskatoon cluster. This chapter offers a summary of the theoretical and empirical observations and presents the reader with some policy lessons for future efforts to develop technology transfer and commercialization partnerships. The chapter concludes with an assessment of the limitations of the study and potential extensions for further research.

6.1. Key findings

The overarching goal of this study was to develop an institutional and behavioural model for technology transfer and commercialization partnerships and to test these theoretical postulates using a case study. The study began with an examination of the existing literature on technology transfer and commercialization partnerships.

The literature analysis offered an understanding of the basic conceptions of such partnerships and highlighted some of the shortcomings of previous studies. The primary limitation observed in past studies was that they failed to provide a comprehensive account of the

underlying factors affecting partnerships. Those studies took a very contextual approach in highlighting the pre-requisites for establishing technology transfer partnerships as well as the impediments faced by these partnerships. Underlying and complicating this is that there was a lack of a 'common language' to describe the functioning of partnerships. Moreover, past studies did not account for the cognitive limitations of the individuals within these partnerships. Consequently, they ended up overlooking key interaction and decision making patterns.

In order to remedy those problems, we have undertaken a comprehensive theoretical review and developed an analytical framework which provides tools to conduct institutional and behavioural analysis of technology transfer and commercialization partnerships. The institutional framework has been built on Elinor Ostrom's IAD framework and makes use of behavioural decision making theories developed by Herbert Simon (1950) and Daniel Kahneman and Amos Tversky (1979).

The IAD framework, developed to deal with common pool situations, provides a set of tools which are flexible enough to be adapted to partnership settings. The framework has allowed us to develop a comprehensive language that can be applied to many similar situations. Using this framework, we have been able to highlight critical institutional factors which can either facilitate or hamper the development of technology transfer partnerships. The key exogenous variables which play an important role in these partnerships include: attributes of the community, biophysical and material conditions, and rules. These variables determine the playing field for participants in partnerships to interact, make decisions, and influence the outcomes. We have argued that rules, both formal and informal, are a critical factor in determining the efficiency and effectiveness of partnerships because they not only affect the action arena, but also evolve over time due to interactions between participants. Therefore, feedback effects in these partnerships

can alter the long term functioning of their operations. Various sets of rules affect the partnership structure and the interactions within it. Rules determining position, boundary, authority, choice, aggregation, information, payoff, and scope are critical in determining various decision-making nodes in the action situation. These rules combined together determine how participants in these partnerships interact and ultimately influence the outcomes.

The focus of analysis, as highlighted previously, also determines the understanding of the entire system. Depending on the level of analysis, one can study how rules affect the interactions at the operational, constitutional, and meta-constitutional levels. It is important to distinguish between these levels, as each level determines the complexity of the action arena and can make it difficult for participants to make decisions under nested action situations. In technology transfer partnerships, which are comprised of organizational actors from academia, public, and private sectors, a complex nesting is always likely to emerge, which can and often does blur the level of analysis.

In addition to the institutional factors, individual behaviours have a strong influence on the interactions and outcomes in a technology transfer partnership. In chapter four, we argued that individuals in complex settings cannot be expected to act perfectly rationally as posited by the traditional rational choice school. Even if and when they do have access to complete information (which is almost an impossible task to achieve in the case of multi-player technology transfer partnerships), they employ different cognitive models to process that information. . Consequently, they end up choosing the option that satisfies their minimum aspiration level. In such situations, individuals may be making decisions that do not satisfy the criteria of comprehensive rationality; however they are not aware of this because of the environmental as

well as cognitive constraints. This line of argument represents 'bounded rationality,' as put forward by Simon (1955).

Another cognitive factor that affects the decisions of individuals in such partnerships is the perceptive framing of problems. It has been argued that individuals perceive and evaluate similar situations differently depending on their framing. If individuals perceive themselves in a domain of gain, they tend to be more risk averse and vice versa. Furthermore, individuals constantly employ various heuristics and biases, which are governed by underlying cognitive systems. These frames, heuristics and biases all influence the decisions being made within collaborative settings. Taken together, risk framing and use of heuristics and biases comprise the theoretical postulates of Prospect Theory (Khaneman and Tversky 1979).

We have argued in this thesis that these cognitive limitations determine the interaction patterns between participants in technology transfer partnerships. The IAD framework thus provides an ideal setting to account for the impact of cognitive capacities on information processing and the extrinsic and intrinsic valuations participants place on different alternatives. In complex situations similar to technology transfer and commercialization partnerships, cognitive limitations can become critical factors in determining the outcomes.

In order to test these theoretical postulates, we developed a case study on the Saskatoon agriculture biotechnology cluster. Through this study, we explored several of these factors as they might have affected the development in 2006-2008 of the Bio-economy Center of Commercialization and Research (BECCR). Individuals from different organizations were interviewed to determine their experiences regarding this particular initiative. The key findings from this case study were then grouped and analysed in the context of the institutional and

behavioural frameworks (Tables 6.1 and 6.2). The surveys reflect an interesting spectrum of diverging opinions and experiences.

Table 6.1. Classification of Institutional Factors

Institutional Factors	Rules	Rules and Formalization
	Biophysical and Material Conditions	Size of Economy and Receptor Capacity Leadership Time Frames Federal and Provincial Politics
	Attributes of the Community	Organizational Cultures University Policies and Administration ILO Structures & IP Policies Trust and Relationships

Source: Author.

Table 6.2. Classification of Behavioural Factors

Behavioural Factors	General perceptions Framing and the win-loss mindset Motivations Entrepreneurial spirit Definition of goals and their interpretations

Source: Author.

The survey findings suggest that from an institutional point of view, community attributes and behavioural factors have exerted a negative influence on the partnership development efforts in the Saskatoon cluster. Participants suggested that developing a long term relationship and trust

was more crucial at the beginning of the process than agreeing on a set of rules. However, as highlighted in chapter five, it was the absence or poor design of various rules that might have played negatively on other institutional variables in the partnership. For example, the scope included a broadly and loosely defined set of technologies, which constrained the ability of organizations to focus on one analytical level and judge the commercial viability of a smaller set of technologies. Furthermore, authority and aggregation rules were found to be absent in this particular initiative, which created leadership problems. Absence of these subsets of rules hampered the attempts to achieve synchronization by developing a common language and agreeing to a mutually beneficial outcome.

Similarly, differences in perceptive framing of the problem had led the participants to assign different values to the proposition. University administrators, many of the public research labs, and most researchers were thought to be in the domain of gains, whereas key project leaders viewed the cluster in a losing position. Other organizations, due to their relatively better performance in the area of technology transfer and commercialization, were also in a domain of gains. These differences in perceptions caused a divergence in participants' goals and motivations. More importantly, these differences led the organizations to hold unfavourable perceptions about their prospective partners, eventually falling prey to the win-loss mindset.

6.2. Limitations of the study

The framework developed here paints the bigger picture with rather broad strokes. However, each of the variables (exogenous and endogenous) in the framework has the potential to be examined in more detail to gain further insights into the effects of the institutional factors on other variables. For example, the effect of these variables on the outcomes has not been

studied here. Therefore, applying the framework in a more intensive and focused way would be an ideal extension to the study.

It may be argued by some that frameworks such as the IAD are too complicated and complex to extend an understanding of technology transfer and innovation systems. While there may be some substance to these criticisms, we propose the following two arguments as a counter to these critiques. Firstly, the IAD framework provides the flexibility to the analyst to choose the level of analysis and allows for modifications in the layout of all or some variables within the institutional structure under study. Secondly, it must be noted that innovation systems and their sub-systems are dynamic and complex systems. To understand these systems a framework should be able to account for the dynamic and simultaneous transformations. The IAD provides such dynamism. While this feature of IAD was not fully utilized in this work as we did not delve into the constitutional and meta-constitutional levels of analysis, such dynamism can definitely be advantageous in the study of innovation systems.

One caveat regarding the BECCR initiative should also be noted. It can be argued that the idea of BECCR was closely linked with the funding opportunity. While the respondents have rightly pointed towards other institutional and behavioural factors which might have generated and then hindered the development, it must be realized that the entire project was predicated upon securing NCE funding. In the absence of funding, the remaining institutional and behavioural factors had diminished significance.

In terms of methodology, these respondents were identified using the snowball technique, which may have missed some critical yet unacknowledged actors. Moreover, the open-ended survey instrument did not provide a set of methodologically sophisticated observations nor are

they analyzed using intensive qualitative techniques. All of the semi-structured interviews were conducted in a back and forth conversational style, where the interviewer (author) asked the participants open-ended questions to which the participants mostly reflected on through their individual experiences. While these interviews allowed us to learn a great deal about the cluster as a whole, it was difficult to scientifically make inferences from the responses. A more focused, methodologically sophisticated survey might provide more consistent observations regarding the functioning of specific aspects of this venture. Creating an index of responses and conducting correlation analysis are a few techniques which might render stronger, more empirically-grounded results.

Furthermore, the questions designed to test behavioural assumptions yielded weak observations. Testing of cognitive framing and other behavioural models can and should involve formal experiments in controlled environments, as have been conducted by many behavioural theorists. Even in the case of controlled experiments, getting the participants in such partnerships to reveal their cognitive framing and their relative domains might be a difficult challenge.

Another consideration is that participants were asked to share their past experiences with the particular partnership initiative. It can be argued that such retrospective reflections may have biased participants' responses. A better option might be to observe the participants during their decision making. However, that might not be possible in reality: to observe decisions first hand is not feasible due to time constraints, confidentiality issues and many hurdles that are faced in real-life situations.

Finally, while we have presented a comprehensive theoretical framework to undertake institutional and behavioural analysis, time and scope constraints did not allow us to test these

theories using a larger population of partnerships. The efforts to develop technology transfer partnerships in the Saskatoon cluster could be compared and contrasted with initiatives elsewhere in North America and Europe.

6.3. Implications and Extensions of Research

The study provides a platform for policy analysts and practitioners to study and analyze the development and management of technology transfer partnerships. It has focused on some key institutional factors that are deeply embedded at different organizational levels and may relate to partners and their engagement.

The findings presented in this study have highlighted key areas which could benefit from policy and administrative reforms. Each organization in the cluster can take a message from this analysis as it applies to their institutional setup. The public sector, for example, can look at their existing initiatives from the perspective of the framework presented in this study and analyze the shortcomings in their policies. Such a policy evaluation could ensure better outcomes which can be explained in terms of institutional and behavioural interactions. Therefore, this study can be thought of as one type of feedback to participants in the partnerships.

The study also allows policy makers to assess the biophysical and material conditions and the attributes of various 'communities' involved in partnerships. An understanding of these two necessary conditions would help policy makers devise comprehensive 'rules' of engagement and decision-making and help them understand the interactions between individuals in complex settings. As we have highlighted, technology transfer and commercialization partnerships, like many other situations in the world, are extremely complex. The framework presented in this

study allows the policy makers and analysts to parse out the relevant action nodes within such partnerships from the underlying organizational structures which enshrine these nodes.

The study has highlighted some key factors which may hinder the development of technology transfer and commercialization partnerships. It therefore gives policy makers a chance to carefully analyze these factors and ensure that effective policies are enacted to remove them from the system. At the most fundamental level the study highlights the role of the government in promoting such technology transfer and commercialization partnerships by providing the feasible conditions which can allow these partnerships to emerge and flourish.

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Appendix 1: Application for Approval of Research Protocol

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Memorandum:

Date: November 15, 2011.

From: Ata-Ul Munim and Peter Phillips
To: U of S Research Ethics Board

Re: **ETHICS REVIEW: VALGEN**

1. Name of advisor:
Peter W.B. Phillips, Johnson Shoyama Graduate School of Public Policy

1a. Name of Student:

Ata-Ul Munim, Candidate for Master of Public Policy-Johnson-Shoyama Graduate School of Public Policy: Master's Thesis

1b. Anticipated start and end date of the research phase.

September 2010- February 2011

2. Title of the Study

Institutional and Behavioural Analysis of Public-Private Partnerships in technology transfer and commercialization

3. Context and Abstract

Even with so much attention being given to innovation and technology production and transfer, much of the effort has not been efficient in generating economic growth through technology commercialization. In Saskatchewan, a few attempts have been made to effectively pool the technologies and disseminate them into the mainstream economy. However, these attempts have not succeeded. Studies related to such research partnerships have not fully explained the reasons behind these failures. This work establishes a framework which will capture the intricacies of technology production and transfer across institutional borders.

This study falls under one of the activities of VALGEN project, dealing with knowledge management. It will specifically look at one of the components of knowledge transfer in the form of technology transfer between various organizations (covered under A2 in the VALGEN project). This research is investigating the efforts, roles and outcomes of the University of Saskatchewan led initiative to create the Bio-Economy Center of Commercialization and Research (BECCR), in an attempt to manage the patent and IP pool of agri-food related technologies in Saskatchewan. This effort in 2005-09 was led by B. Laarvald and S. Smyth of University of Saskatchewan and involved discussions and negotiations with NRC, AAFC, SRC, AWB and various others in the Saskatoon-based agri-food cluster.

The purpose of this study is to develop an institutional and behavioural analysis of public-private partnerships in order to promote effective technology transfer and commercialization. In terms of institutional analysis, a framework will be developed to account for the effects of exogenous variables such as rules, attributes of the community, and biophysical conditions. The framework will facilitate analysis of the problem in a given frame, and unpack how various participants addressed the problem. The study will also undertake a quasi-behavioural analysis in order to find out about how individual motivations, perceptions, and cognitive framing might exert a feedback effect on the problem and exogenous variables as well as the outcomes.

This specific ethics request is to conduct interviews with those individuals involved in initiating such efforts at the University of Saskatchewan as well as other related organizations.

4. Funding

VALGEN

5. Participants

The participants in this case study will be selected on the basis of their involvement with the specific partnership. These include department heads, project leads, and senior management officials of various organizations. The shortlist of those to be interviewed involves 8-10 individuals from those organizations who were involved in the partnership development process at some stage. The list may be expanded further if leads are generated during the research/interview process. These are the individuals who are experts in their respective areas and are sophisticated respondents. In all cases, the individuals will be authoritative. Most of the individuals have been contacted and they have expressed willingness and interest in participating. The formal enrolment letter is attached.

6. Conflict of Interest

No conflict of interest situation can be foreseen to be arising in this study.

7. Consent

All researchers are able to drop out of the survey/relationship at any time. Research goals, methods, and results will be fully disclosed to all participants. These messages will be conveyed in the formal letter of enrolment.

Once the interviews have been conducted, all individuals will be anonymyzed before the data is used for further research purposes. All identifying codes will be kept confidential.

9. Methods/Procedures

In-person and/or telephone interviews will be used to conduct the attached semi-structured interview. These questions will be open ended in order to garner a broad description from the participants.

10. Storage of Data

Permission will be sought from the participants to tape and/or make notes of the interviews, which will be kept in the possession of the primary researcher and/or his advisor. All data will be kept in files in the offices of Dr. Phillips. As per University regulations, as the lead researcher and supervisor, I commit to securely store the data at the University of Saskatchewan for a minimum of five years upon the completion of the study.

11. Dissemination of Results

The data collected will be used to inform the case study which is part of a MPP dissertation. The responses collected from the interviews will be used to support the theoretical arguments built around institutional and behavioural factors affecting the effectiveness of research partnerships developed to promote technology transfer and commercialization.

12. Risk, Benefits, and Deception

We do not foresee any specific risks. This is a knowledgeable and professional population that will benefit from the research directly. The purpose of the research is to assess the effects of institutional procedures and behavioural factors on the success/failure of technology transfer partnerships.

13. Confidentiality

Once the interviews have been conducted, all individuals will be anonymyzed. No results will be released that can be used to identify an individual. Only system results and aggregates will be reported. No direct quotations will be used.

14. Data/Transcript Release

N/A.

15. Debriefing and feedback

The results will be part of the thesis which has been undertaken as part of the requirements for master of public policy. These results will be incorporated in the dissertation and presented to the thesis committee during thesis defence.

16. Required Signatures